

**TARTU STATE UNIVERSITY
DEPARTMENT OF SURGERY**

**PUBLICATIONS
ON VASCULAR
SURGERY
AND UROLOGY**

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P R E F A C E

The papers published in the present collection have been written by members of the staff of the Chair of Surgery of Tartu State University and their colleagues working chiefly in the surgical departments of the Tartu Municipal Clinical Hospital.

Problems of vascular surgery and urology have been the traditional field of research for surgeons and other medical scientists in Tartu. Already in the nineteenth and the early twentieth century such professors of Tartu University as N.I. Pirogov, R. Thoma, E. Wahl, W. Zoege Manteuffel, N. Burdenko and others thoroughly studied the topography, pathomorfology and treatment of vascular diseases. In the twenties and thirties of the present century, Prof. A. Linkberg and Prof. L. Puusepp were engaged in the diagnosis and treatment of the vascular diseases of the extremities and of the brain, applying angiographic methods of research.

In the period following World War II the above-mentioned problems have been continuously studied by the staff of the Chair of Surgery of Tartu State University as well as by surgeons working in the departments of vascular surgery and urology of the Tartu Municipal Clinical Hospital. The principal line of research has been vascular pathology and in particular the diagnosis and treatment of occlusive diseases. Thus, over 300 reconstructive operations have been performed on the main arteries. The subjects of study have also included coronary heart disease, the pathology of veins and other problems of vascular surgery. Research into urology has primarily been concerned with the treatment of abnormalities of the urogenital organs and renal insufficiency. In the vascular surgery and artificial kidney departments members of the staff of the Chair are also engaged in solving

problems connected with kidney transplantation in the Estonian S.S.R.

The authors express their thanks to the late O. Haas for translating and to Assistant Professors L. Kivimägi and O. Mutt for help in editing the articles in this collection.

Professor A. Linkberg, M.D., F.I.C.S.,
Head of the Chair of Surgery

Results of Operative Treatment of Arterial Emboli and Acute Thromboses in 80 Patients

E. Tünder, K. Pöder, H. Tikko, K. Kull, L. Roostar

A rapid development in the field of vascular surgery has made it possible to apply operative treatment of arterial emboli and acute thromboses more extensively. Beginning with 1960, systematic operative treatment has been introduced for patients with acute thromboses and emboli in the Department of Vascular Surgery of the Tartu Clinical Hospital. Patients are admitted to this Department for operative therapy from the whole of the Estonian SSR. During the past five years, i.e. in the period of 1963 - 1967, 80 patients were treated in this Department. 60 of them (40 men and 20 women) underwent operative treatment. In the remaining 20 patients neither thromb- nor embolectomies were performed because of established gangrene or the peripherious location of a lesion in the calf or forearm arteries. Fibrinolysine and anticoagulants (heparin, fenilin) therapy was applied in patients with peripherious lesions. The patients operated on fell into three age groups: a) younger than 45 years - 7, b) 46 - 60 years - 19 and c) older than 60 years - 34 patients. According to the location of emboli or acute thromboses the patients were grouped as follows: (1) lesion in the aortic bifurcation - 6 patients; (2) lesion in the iliac artery - 7 patients; (3) lesion in the femoral artery - 18 patients; (4) lesion in the popliteal artery - 10 patients; (5) lesion in the arteries of the upper extremities - 19 patients.

Arterial emboli were observed in 33 and acute thromboses in 27 patients. Due to repeated embolism in a number of patients we had 67 acute thromboses or emboli in 60 individuals.

In cases of arterial occlusion lasting for a longer period of time, the formation of secondary thrombosis was observed in the patients who could not be operated on during the first 12 - 24 hours due to their late hospitalisation and in whom immediate anticoagulant therapy had not been applied. Thus in 30 per cent of those operated on the ascending distribution of thrombosis and in 50 per cent the descending distribution in the main arterial trunk and sometimes in its branches were observed. The formation of secondary thrombosis, especially the distribution of thrombosis distally, into the terminal portion of the popliteal artery and the calf arteries and also the formation of thrombosis in the corresponding veins is one of the main reasons for considerably worse results of operative therapy in a later period.

The therapeutic results of surgical treatment are the better the earlier procedures are started.

The operation was performed during the first 12 hours in 21 patients, during the first 24 hours in 35 patients (58.3 per cent of all the cases).

Out of 67 operations in 52 cases only a thromb- or embolectomy was performed. 15 patients with intensive atherosclerotic stenosis in the region of thrombosis were simultaneously subjected to reconstructive operation, endarterectomy or by-passing. It must be pointed out that the simultaneous occurrence of obliterative atherosclerosis is one of the main causes for the formation of arterial thrombosis. Extensive emergency reconstructive operations are often impossible in patients with obliterative atherosclerosis who have thrombosis or emboli because of their bad general condition due to their advanced age and lesions in essential organs. This is one of the reasons for the worst results of surgical therapy in this group of patients.

Methods for performing operations do not differ from those generally used. Both general and local anaesthesia

were applied depending on the general condition of the patient and the kind of operation to be performed. In the course of the operation 2,500 - 10,000 units of heparin diluted in physiological solution were administered into the artery operated on. During the postoperative period anticoagulants were used.

When estimating the results of operative therapy, the patients were divided into four groups: 1. Restoration of blood supply in the extremity. Pulsatile flow was restored in the peripherous arteries (a. radialis, a. dorsalis pedis, a. tibialis posterior). 2. Improvement of blood supply in the extremity without the restoration of pulsations on peripheral arteries. In these patients the complete restoration of blood flow was usually not achieved because of atherosclerosis or arterial thrombosis distally from the operation area. Better blood supply was achieved as a result of restored circulation in the main trunk of the operated artery and large collateral branches originating from it. 3. Formation of gangrene. The operation did not result in the restoration or improvement of circulation. 4. Cases ending in death. In a number of patients who died in the later postoperative period the restoration or improvement of circulation was achieved as a result of the operation, in others gangrene had developed.

Results depending on the time of operation, and the location of arterial thrombosis or emboli are presented in Tables 1 and 2.

Judging by these tables blood circulation was restored or improved in patients after thromb- or embolectomies on 49 ischemic extremities out of 67 (73.1 per cent).

In our patients better results were achieved in the operations on the femoral artery and in the arteries of the upper extremities, and in the patients who were operated on during the first 12 hours.

In patients who had been preliminarily treated with anticoagulants to avoid the distribution of thrombosis in

Table 1

Results of thromb- and embolectomies depending
on the operation time

Opera- tion time	Re- sults	Number of opera- tions	Blood supply		Forma- tion of gan- grene	Deaths	
			re- stora- tion	im- prove- ment		after the resto- ration or im- prove- ment of blood supply	with gan- gre- ne
Earlier than 12 hours		25	15	6	4	2	1
13-24 hours		10	3	5	2	3	-
2-3 days		15	8	2	5	2	2
More than 3 days		17	5	5	7	-	1
Total:		67	31	18	18	7	4

Table 2

Results of thromb- and embolectomies
depending on the location of arterial thrombosis or
emboli

Lo- ca- tion of throm- bosis or emboli	Re- sult	Number of opera- tions	Blood supply		Forma- tion of gan- grene	Deaths	
			re- stora- tion	im- prove- ment		after the resto- ration or im- prove- ment of blood supply	with gan- gre- ne
1	2	3	4	5	6	7	8
Aortic bifur- cation		6	-	3	3	1	1
Iliac artery		8	4	-	4	1	2

1	2	3	4	5	6	7	8
Femoral artery	20	8	9	3	4	-	
Popliteal artery	12	5	3	4	-	-	
Arteries of upper extremity	21	14	3	4	1	1	
Total:	67	31	18	18	7	4	

the main arteries and who had no established gangrene because of good collateral circulation, the restoration or essential improvement of blood circulation in the extremity was achieved for the later period as well. Consequently, as a result of thromb- or embolectomy blood circulation in 58.8 per cent of ischemic extremities was restored or improved if the disease had not lasted for longer than three days.

During the postoperative period 11 patients died, i.e. 18.3 per cent of those operated on.

7 patients (63.6 per cent) of those who died in the later postoperative period had restored or essentially improved blood circulation in the extremity.

Death was immediately caused by pulmonary, mesenteric or brain artery embolism in 3 patients, by a severe heart disease in 6 and by general intoxication in 2 patients. All the patients who died were older than 60 years and had suffered from severe diseases, such as myocardial infarction, rheumatic endocarditis and general atherosclerosis of blood vessels.

In our patients better operative results were achieved in those with embolism in the femoral and the upper extremity arteries. The results were so much the better, the sooner the operation was performed and the less expressed were the obliterative atherosclerotic lesions in the arteries operated on.

Operative-Technical Measures to Prevent Complications in Reconstructive Vascular Surgery

E. Tünder, K. Kull, H. Tikko, K. Pöder

In the present article the results of reconstructive operations performed on arteries are analysed, paying particular attention to the complications occurring in these operations. Severe complications may arise during the operation, immediatly after it and also during the late postoperative period after reconstructive operations on the extremity arteries (1, 2, 3).

In the present paper we discuss complications the number of which can be reduced by applying our improvements on operational techniques beginning with 1964 (4). During the years 1960 - 1967 more than 300 reconstructive operations have been performed on the arteries of the lower extremities to treat advanced insufficiency of arterial blood supply at the Department of Vascular Surgery of Tartu Surgical Hospital. The mortality rate in these operations reached 10 per cent. 2 per cent of the deaths were caused by complications due to severe infections in the operational area or in the graft.

One of the main complications was extensive infection developing in the groin incision region and spreading to the graft in the aorto-iliac or femoro-popliteal region. In these patients an incision for exposure of the femoral artery immediately under the inguinal ligament was made at the projection level of the artery (5).

From the foregoing one may assume that the development of infection in the groin region wound originates from the groin lymphatics and nodes injured during the operation.

In order to avoid infection while exposing the common femoral artery, we applied the following method (see Fig. 1).

A skin incision of 10 to 15 cm begins at the level of

the spina iliaca anterior superior and goes distally parallel to the femoral artery. The skin and the subcutaneous tissue are transected up to the sheath of the sartorius muscle. In the described way we avoided damaging lymph nodes and lymphatics in the groin region as they are situated more medially. After that the sheath of the sartorius muscle is opened and the muscle is drawn laterally. In order to expose the upper third of the femoral artery

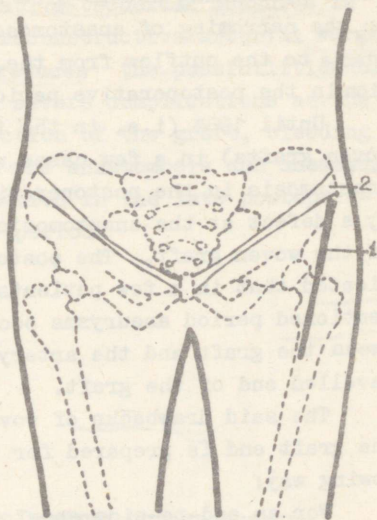


Fig. 1.

we penetrated through the posterior lamina of the sheath of the sartorius muscle /5/.

After having introduced the described lateral incision for exposure of the upper third of the femoral artery in reconstructive operations, our operative wounds in the groin region healed primarily. That is why during the past three years in the grafting operations on the aorto-femoral or femoro-popliteal arteries we have not noted any infections originating from an operative wound in the groin region.

A number of complications concurring with arterial by-passes are connected with the graft structure. That is why judging by the data in the literature knitted grafts are preferred to woven grafts in performing these operations. One of the main drawbacks of the woven grafts is considered to be the unravelling of their ends. Due to

their unravelling, additional sutures must often be placed while performing end-to-side anastomoses, which may lead to the narrowing of anastomoses. This may cause an obstacle to the outflow from the graft and lead to an occlusion in the postoperative period.

Until 1964 (i.e. in the initial period of introducing woven grafts) in a few cases we noted bleeding from the anastomosis in the postoperative period. It was caused by a defect at the anastomosis due to the unravelled end of the woven graft. The postoperative follow-up also indicated that in a few patients operated on in the above-mentioned period aneurysms occurred in the anastomosis between the graft and the artery obviously caused by the unravelled end of the graft.

The said drawbacks of woven grafts can be avoided if the graft end is prepared for the anastomosis in the following way:

For an end-to-side anastomosis the graft is cut diagonally under an angle of 45° , whereas the cutting line is not straight but "wavy" (Fig. 2) /5/.

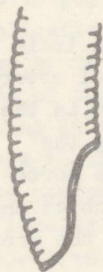


Fig. 2. For an end-to-side anastomosis the graft is cut diagonally under an angle of 45° , whereas the cutting line is not straight but "wavy" (Fig. 2) /5/. If we cut the graft end in the manner shown in the figure and join it to the side of the artery, the distal portion of the end-to-side anastomosis remains wider (Fig. 3). While performing an anastomosis, the preparation of the graft end in the above-mentioned manner makes it possible without a narrowing of the anastomosis to embrace the edge of the woven graft more deeply (1.5 to 2 mm) into the suture thus preventing its unravelling. That is why during the past three years we have not noticed any complications in the end-to-side anastomosis region between the graft and the artery caused by the unravelling of the woven graft.

Judging by our experience we can conclude that the

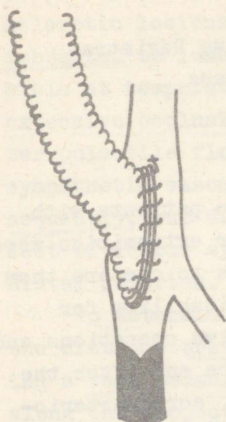


Fig. 3.

application of the above-described operative-technical measures in the reconstructive arterial surgery reduces the possibilities of such severe complications as the infection of the graft, bleeding from the anastomosis, and aneurysm formation in the late postoperative period.

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Systolic Pressure Gradient and Pulse Registration in Peripheral Vascular Disease

H. Tikko, E. Tünder, K. Pöder

^{angiography}
Hemodynamic alterations occurring in patients with obliterative atherosclerosis of the lower extremities were studied, using different research methods to compare them with each other and to estimate their suitability for establishing indications for reconstructive operations and the evaluation of surgical effect. Before and after the by-pass grafting or thrombendarterectomy, aorto-arteriography, blood pressure and pulse wave registrations by direct and indirect methods, electric impedance plethysmography, oscillometry, determinations of skin temperature and oxygen saturation of venous blood were carried out.

The results of blood pressure determinations and pulse wave registrations by indirect methods are discussed in the present paper.

Research Methods

Systolic blood pressure was measured at four different levels of the leg (high thigh, low thigh, high calf and low calf) together with the simultaneous pulse wave registration on the great toe with Whitney-type mercury in a rubber strain gauge plethysmograph. For the determination of blood pressure a standard mercury manometer with a 14-cm-wide occluding cuff was used. Lowering the pressure in a cuff inflated in excess of a systolic pressure, the systolic pressure under the cuff level was recorded at the moment a pulse wave appeared in the toe. The appearance of the pulse wave was observed on the oscilloscope and the waves were registered simultaneously with the electrocardiogram by means of an oscillograph N-102 on a 24 mm filmstrip at a speed of 25 mm per sec.

Investigations were performed in the supine position

of patients. In case of less extensive or moderate atherosclerotic lesions and in patients who had previously been subjected to lumbar sympathectomy, registrations were possible at temperatures of $+19$ to $+25^{\circ}$ C. In case of more extensive occlusive involvements, it was possible to register pulsatile flow in the great toe after the release of sympathetic vasomotor tone by indirect heating only. Consequently, our diagnostic method proves the beneficial effect of lumbar sympathectomy on hemodynamics in the leg distal arteries.

To determine the transmission speed of the pulse wave, the distance travelled by the pulse wave was obtained using a tape measure from the sternal angle to the great toe along the projection of the aorta and leg arteries. To this figure 13 cm was added to account for the length of the aortic arch. Pulse transmission time was read from the electrocardiogram as the interval from the Q wave to the pulse curve intercept less than 0.08 sec. Transmission speed was expressed in cm per sec. Systolic slope time was recorded from the film in seconds.

In order to estimate the relative severity of atherosclerotic lesions and to compare the extent of disturbances of the circulation in various patients, systolic blood pressure was expressed not only in mm Hg., but also in the percentage of the systolic pressure in the upper arm. The expression of systolic pressure as percentages of the patient's general systolic pressure is necessary because its values distal from the atherosclerotic occlusions or stenoses depend not only on the severity of atherosclerotic involvement and the degree of collateral circulation, but also on the general blood pressure, being extremely different in various patients. It is of particular significance to compare the relative severity of hemodynamic disturbances in different patients based on the value of the systolic pressure in the upper calf expressed as percentages. This determination level is usually distal

from the atherosclerotic lesions commonly occurring in the aorto-iliac or femoro-popliteal regions.

The control group for the investigations performed in atherosclerotic patients consisted of healthy individuals of the same age.

Results and Discussion

The ^{measurements} measurements of the systolic pressure at various levels were performed before reconstructive operations in 58 patients and after it in 44 patients. Registrations in the control group were performed in 21 persons. The mean values in the control group were as follows:

Statis- tic values	Systolic pressure in per- centage. Upper thigh	Difference of pres- sures be- tween up- per and lower thighs in mm Hg.	Difference of pres- sures be- tween lower thigh and upper calf in mm Hg.	Systolic pressure in per- centage. Upper calf	Difference of pres- sures be- tween up- per and lower calves
\bar{X}	109.1	5.4	5.5	100.4	5.1
m	0.3	0.4	0.3	0.5	0.3
s	1.4	1.7	1.4	2.3	1.4
n	21	21	21	21	21

The pressure gradient between any two successive levels in the control group did not ^{exceed} exceed 10 mm Hg. Consequently, such values of the pressure gradient are normal and ^{exclude} exclude the existence of hemodynamic disturbances between the measurement levels.

According to our data, a gradient between two neighbouring levels of 15 or more mm Hg is pathological and refers to the occlusion or significant stenosis of arteries between the measuring levels. The method applied makes it possible to determine the extent and location of occlu-

ion or stenosis and to estimate quantitatively the severity of hemodynamic disturbances measured in absolute values (mm Hg.) or expressed as percentages of the patient's general blood pressure. At the same time the method makes it possible to determine the patency of the arterial tree distal from its atherosclerotic involvement by the absence of pathological pressure gradients. Thus, the average gradient between the upper and lower calves of the patients with obliterative atherosclerosis in the aorto-iliac or femoro-popliteal arteries was 8 ± 0.3 mm Hg.; $s = 2.3$ mm Hg. The possibility for the determination of the patency of arteries distal to atherosclerotic occlusions or stenoses is extremely valuable in cases the single aorto-arteriogram gives no information about the state of the popliteal and calf arteries.

According to their location, the atherosclerotic lesions in the arteries of the lower extremities are divided into 3 groups. The first includes the lesions in the aorto-iliac region; the second, occlusions and stenoses of the femoral artery; the third, the involvement of the popliteal and calf arteries.

In the occlusions and stenoses of the abdominal aorta and the common and external iliac arteries the systolic pressure values in the leg were lower than normal compared with the values in the upper arm. At the same time the pressure gradients of the leg were normal. According to our data, the diagnosis of iliac artery stenosis is possible if at least 50 per cent obstruction of the aorto-iliac arteries is demonstrated aortographically. In these cases the systolic pressure in the upper thigh was always less than 90 per cent of the pressure in the upper arm. Let us recall that in the control group the mean systolic pressure in the upper thigh consists of 109.1 ± 0.3 per cent; $s = 1.4$ per cent. The more extensive the stenosis of the iliac arteries, the more expressed was the drop of the systolic pressure in the upper thigh ($r = -0.547$; $p < 0.02$).

In the occlusions or stenoses of the middle and lower thirds of the femoral artery the systolic pressure in the upper thigh was normal, in the lower thigh and distally it was lowered. As in special cases of measurement, a little lowering of the pressure in the upper thigh in patients with patent aorto-iliac arteries refers to the high occlusion of the femoral artery beginning under the occluding cuff. In such patients the systolic pressure in the upper thigh was somewhat lower than normal, but at the same time it was more than 90 per cent of that measured in the upper arm. So the lowering of systolic pressure caused by the high occlusion of the femoral artery can be distinguished from the lowering caused by the stenosis of the iliac arteries for more than 50 per cent. In the first case the systolic pressure in the upper thigh was always higher than 90 per cent, in the second case it was always lower than 90 per cent of the systolic pressure in the upper arm.

In the lesions of the popliteal artery the gradient of systolic pressure became pathological between the lower thigh and upper calf measurements.

In the occlusions of the calf arteries the pathological gradient of systolic pressure is localized between the measurement levels in the calf.

In the simultaneous occlusions or stenoses in the aorto-iliac and femoro-popliteal regions the pathological systolic gradients were observed at both levels.

The main drawback of the method applied lies in the difficulty of determining the severity of the lesion in the aorto-iliac region with the simultaneous high occlusion of the artery. Estimating the systolic pressure in the upper thigh of such patients a decrease in pressure is also caused by the high occlusion of the femoral artery remaining under the occluding cuff. The reduction data of systolic pressure at this level are 10 to 15 per cent higher than the drop due to the atherosclerotic involvement of the aorto-iliac arteries. The gradient values caused by the occlusion of the femoral artery in these patients are under-

estimated for the same rate. The underestimation of the extent of the distal block in patients with such lesions does not cause any difficulties in diagnosing the occlusions of the femoral artery, because the gradient between the upper and lower thigh always exceeds 15 mm Hg.

The values of systolic pressure in the upper calf expressed as percentages varied greatly in different patients from 30 to 73 per cent ($\bar{x} = 57 + 1.3$ per cent; $s = 10.9$ per cent). This indicates a great difference in the severity of hemodynamic disturbances in different individuals.

The given method proved to be of great value in determining the effect of reconstructive operations. In order to establish the efficiency of performed operations we compared the values of blood pressure in the upper calf expressed as percentages and measured before and after the procedure with the corresponding values of the control group (100.4 ± 0.5 per cent; $s = 2,3$ per cent).

After the restoration of disturbed hemodynamics the systolic pressure in the upper calf, as a rule, exceeded 90 per cent of the pressure in the upper arm. The values of 90 per cent or less demonstrate the occurrence of certain disturbances in the reconstructed region and should be estimated as a poor prognostic sign considering the long-term patency of the graft or the thrombendarterectomized segment of the artery.

The patients who underwent a reconstructive procedure in the aorto-iliac region while the occlusion of the femoral artery remained (the revascularization of the extremity via the profound femoral artery) indicated a limited rise in blood pressure at the level of the upper calf. In such patients the rise reached 4 to 15 per cent of the systolic pressure in the upper arm and depended on the extent of both the removed block in the aorto-iliac region and that remaining in the femoro-popliteal region. In these patients systolic the pressure in the upper calf

constitutes 49 to 83 per cent of that in the upper arm ($\bar{x} = 63 \pm 2.6$ per cent; $s = 8.2$ per cent).

The measurement of blood pressure by the given method at the level of the upper calf, thanks to its simplicity, is highly suitable for repeated check-up of the late results of reconstructive operations.

Before reconstructive operations the pulse wave was registered in 49 patients and after the operation in 30 patients. The investigation of the control group was carried out in 20 individuals. Compared with the control group in patients with occlusions and stenoses of arteries, a delay in systolic and diastolic slopes and the absence of dicrotic waves in the sphygmogram were observed. The systolic slope time and the shape of the pulse wave differed greatly with different patients. In more expressed disturbances of the circulation in the extremities pathological changes in the pulse contour were more pronounced. Extensive atherosclerotic lesions in the popliteal or the calf arteries, being usually counterindications for reconstructive procedures, were not observed in patients with a good or adequate collateral pulse curve. Thus an arterial pulse curve of adequate amplitude refers to the segmental character of atherosclerotic lesions and the patency of distal circulation. Such patients can usually be subjected to certain types of reconstructive operations.

In the control group the acceleration of the pulse wave distribution was noted together with an advance in the age of individuals ($r = 0.726$; $P < 0.001$). In the obliterative and stenosed blood vessels the distribution of the pulse wave, diminished ($P < 0.001$) as compared with the control group. The average speed of wave distribution in patients with obliterative atherosclerosis was 682 ± 13 cm/sec., $s = 92$ cm/sec. while it was 944 ± 23 cm/sec., $s = 97$ cm/sec. for the control group.

The distribution speed of the pulse wave in patients with obliterative atherosclerosis is influenced in the

contrary directions by two factors: acceleration of distribution as a result of sclerosis and its retardation in the collaterals and in the portion of the main artery with a low pressure distal from the obstruction. Occlusions and stenoses are of greater influence on the distribution speed (lowering) than the sclerotic changes of the arterial wall (acceleration). This conclusion also corroborates the fact that there is no correlation between the age and distribution speed in patients with obliterative atherosclerosis ($r = 0.159$; $P > 0,10$).

The distribution speed of the pulse wave and the data on systolic pressure at the upper calf level expressed as percentages (the latter being characteristic of the extent and severity of the atherosclerotic involvement) are correlated ($r = 0.320$; $P < 0.05$). Together with the growing severity of the atherosclerotic involvement, together with a more severe drop in the blood pressure, the reduction of the distribution speed of the pulse wave as more pronounced

The systolic slope time in patients with obliterative atherosclerosis increased ($P < 0.001$). The average values of the systolic slope time in the control group were 0.14 ± 0.004 sec.; $s = 0.02$ sec. and in patients with obliterative atherosclerosis - 0.25 ± 0.008 sec.; $s = 0.05$ sec.

After the elimination of occlusions or stenoses a rise in the distribution speed of the pulse wave ($P < 0.001$) at an average of 311 ± 33 cm/sec. was observed. At the same time the systolic pressure slope time decreased ($P < 0.01$) at an average of 0.08 ± 0.03 sec.

The distribution speed of the pulse wave after the reconstruction of blood flow was greater than in the control group ($P < 0.02$). The average distribution speed in patients with reconstructed blood flow was 1028 ± 27 cm/sec.; $s = 119$ cm/sec. while it was 944 ± 23 /cm/sec.; $s = 97$ cm/sec. in the control group. Such differences were obviously caused by the fact that sclerotic changes in the reconstructed arteries were more pronounced than in the con-

trol group. In patients with obliterative atherosclerosis after the reconstruction of blood flow the distribution speed of the pulse wave was not correlated with the age of the patients ($n = -0.08$; $P > 0.10$).

As such correlation existed in the control group, it should be assumed that by-passing or thrombendarterectomy influenced the distribution speed of the pulse wave at least in a number of patients. This conclusion is also supported by the circumstance that the mean values for the systolic slope time (0.16 ± 0.007 sec.; $s = 0.03$ sec.) in patients with successfully performed reconstructive operations was somewhat higher ($P < 0.05$) than that of the control group. (0.14 ± 0.004 sec.; $s = 0.02$)

Having abolished the block in the aorto-iliac region in patients with a remaining occlusion in the femoral artery an increase in the pulse wave speed was also noted ($P < 0.01$) at an average of $85 + 20$ cm/sec. The systolic slope time also diminished ($P < 0.05$) at an average of 0.06 ± 0.02 sec.

Conclusions.

(1) The present indirect method of systolic pressure determination at different levels of the lower extremity together with simultaneous pulse wave registration on the great toe makes it possible to determine the location, extent and severity of atherosclerotic occlusions and stenoses of arteries. At the same time it is possible to determine the patency of the arterial tree distal from its obliterative involvement.

(2) The quantitative estimation of the severity of hemodynamic disturbances and comparison of its extent in various patients is possible by measuring systolic pressure distal from the obliterative involvement of the arteries and expressing it as percentages of the patient's systolic pressure in the upper arm.

(3) The given simple method proves to be of great

value in determining quantitatively the effect of reconstructive procedures and evaluating the immediate and long-term results of such operations.

(4) The pulse wave distribution speed increases with advancing age. In patients with obliterative atherosclerosis the distribution speed is retarded and the systolic slope time prolonged. The severer the obliterative involvement of the arteries, the more pronounced is the reduction of the distribution speed of the pulse wave.

Vasographic Methods and their Complications in the
Diagnosis of Atherosclerotic Lesions of the Arteries

K. Kull, E. Tünder, H. Tikko, K. Pöder, T. Sulling

The diagnosis of blood circulation insufficiency in extremities and organs and the elaboration of therapeutic methods for its treatment are the main problems in vascular surgery. Although various diagnostic methods have been elaborated in recent years (oscillography, sphygmography, plethysmography, blood pressure measurement in different segments of the extremity, determination of blood pressure by direct method, electrical thermometry, ergometry, etc.) and rich clinical experience has been accumulated, the need for contrastive research methods cannot be discarded, but grows from year to year. This is due to the fact that vasographic investigations make it possible to diagnose the location and character of the lesions, the extent of collateral circulation and to perform differential diagnosis.

Arteriography has been applied for the diagnosis of obliterative vascular diseases in the lower and upper extremities in the Department for Vascular Surgery of Tartu Surgical Hospital since 1957. Since 1962 translumbar aortography and beginning with 1965 catheter aortography after Seldinger have been performed. Thoracic aortography and coronarography were introduced in 1966.

The following table gives a survey of the extent of vasographic investigations performed.

According to the table, 1,814 vasographic investigations were made in arteries. Of the arteriographies the majority were performed in the femoral artery by the percutaneous puncture method. It was usually applied for the

Method	Number of procedures
1. Arteriography in the arteries of extremities	1064
2. Translumbar aortography	493
3. Abdominal aortography after Sellinger	198
4. Thoracic aortography	49
5. Coronarography	20

diagnosis of obliterative atherosclerosis and obliterative endarteritis, more seldom in traumatic injuries, aneurysms and acute thromboembolic diseases. The results of our investigations showed that the atherosclerotic lesions of the peripheral arteries may lead to extensive obliterations of the femoral and popliteal arteries. But there also occur more limited occlusions, which are localized mainly in the Hunter canal region.

In case of arteriography in the femoral arteries, simultaneous arteriography of the calf arteries with a delay of a few seconds was performed by another X-ray apparatus. If the calf arteries were not contrasted in the roentgenogram and it was inevitable to establish their state, arteriography was performed through the popliteal artery during the operation.

Arteriographic procedures in the arteries of the upper extremities were performed in their lesions, traumatic injuries, thromboembolic lesions and in cases of the Takayashu syndrome.

Cardiotrast and diodone of 50 to 70 per cent in a dose of 15 to 20 cm³ were administered in aorto- or arteriography without complications.

Translumbar aortography was performed in atherosclerotic lesions of the terminal part of the abdominal aorta and the iliac arteries. According to our experience and

data in the literature /A.C. Beall et al., (1)/ this method must be considered as a choice method in the diagnosis of atherosclerotic lesions in the aorto-iliac region.

The location, extent and character of the lesion and also the development of the collateral circulation are determined by aortography. The varieties of the Leriche syndrome can be explained by this research method in each particular case and the unilateral or bilateral nature of the lesion in the iliac arteries can be determined. The involvement of the internal iliac artery by the atherosclerotic process, essential from the standpoint of the collateral circulation, can be explained /E.V. Potyomkina, (2)/.

With a delay of a few seconds to translumbar aortography we exposed by another X-ray apparatus the femoral and popliteal arteries by placing another X-ray folder under the thighs of the patient. So we obtained roentgenograms of both the aorto-iliac and femoro-popliteal arteries by means of one injection of the contrast medium. In aortographic procedures we used cardiostast and diodone of 70 per cent solutions, triumbrene (70 per cent), triotrast (70 per cent), hypaque (85 per cent) and urographine (76 per cent). The contrast medium was injected in a dose of 20 to 25 cm³.

Our results in the aorto-iliac region of atherosclerotic lesions showed that aortic lesions constituted 14.2 per cent, lesions in the common iliac arteries - 64.7 per cent, lesions in the external iliac arteries - 21.1 per cent of the cases under investigation. Together with the lesions in the aorto-iliac region, about 75 per cent of the patients also had lesions in the femoral, popliteal or tibial arteries. This fact is of great significance for operative therapy.

Abdominal aortography by the Seldinger method was performed in patients with no lesions in the iliac arteries to diagnose the atherosclerotic lesions in the vis-

ceral branches of the abdominal aorta. By this method hypertension caused by the stenosis of the renal artery was noted in 17 cases. In 3 cases stenosis was discovered in the superior mesenteric artery, which was considered to be the cause of the abdominal angina. In other cases abdominal aortography was applied in the diagnosis of various kidney diseases.

Thoracic aortograms were performed after Seldinger via the femoral artery. This procedure was mainly used in the Takayashu syndrome to determine the location and character of lesions in the aortic arch and the arteries originating from it. Thoracic arteriography was also done in patients with thoracic aneurysms.

Coronarography was also performed by the Seldinger method via the femoral artery. Coronarography and thoracic aortography were performed under the conditions of reduced blood circulation (intrabronchial pressure was elevated), making it possible by means of a limited amount of contrast medium to obtain contrastive angiograms of coronary and brachiocephalic arteries.

In spite of its great diagnostic value, aortography may lead to severe complications. Next we shall discuss complications occurring in our materials.

Most frequent complications in translumbar aortography were due to technical mistakes. These complications are presented in the following table.

It turns out that out of 493 cases of translumbar aortography we had paraaortal injections in 6 cases (1.2 per cent). In 3 patients all the contrast medium was injected into the paraaortal tissue and in 3 patients a portion of contrast medium was injected into the aorta, but a portion into the paraaortal tissue. In these cases, without removing the needle from the paraaortal tissue 100 - 120 ml of 0.25 per cent procaine solution was injected. Procaine considerably diluted the contrast medium of high concentration, reducing its harmful effect on the

Table 2.

Technical mistake	Number of failures	Number of severe complications
1. Injection of contrast medium into the para-aortal tissue		
(a) partial	3	-
(b) complete	3	-
2. Intramural injection of contrast medium		
(a) partial	17	-
(b) complete	5	1
3. Injection of contrast medium into the branches of the aorta	10	-
T o t a l	38	1

tissues and facilitating its resorption. Besides, procaine also anaesthetized the paraaortal tissue. The patients felt tolerable pain for 1 hour after the paraaortal injection of contrast medium, then the pain became less and fully disappeared in 4 to 5 hours. The roentgenological investigation one hour after the injection of contrast medium showed that the shadow of the paravasate was weak or missing. Roentgenographic exposures on the next day did not reveal any traces of paravasates. Aortographic studies in these patients were repeated 3 to 10 days later without causing any harm.

Intramural injection was performed in 22 patients. In most cases the aortic wall was extremely sclerotic. Intramural injections of the contrast medium can be explained as follows: The tunica media and tunica intima are loosely connected due to calcification of the aortic wall. During

the procedure, the end of the needle after passing the tunica media does not go through the tunica intima, but dissects it. In advanced sclerosis the tunica intima is ulcerous in places and tears easily. This is why a pulsatile blood jet flows out of the needle creating the impression as if the end of the needle were in the lumen of the aorta. Injecting now the contrast medium, it flows in between the tunica media and the tunica intima, and the pushed-off tunica intima forms a block and closes the passage for the contrast medium.

If a small amount of contrast medium (up to 10 ml.) was injected between the layers of the aortic wall, it did not cause serious disturbances. In 5 patients the whole amount of contrast medium (20 to 25 ml) was injected intramurally and they suffered from severe pain in the back and the lower part of the stomach. In three of these patients the pain disappeared after 15 minutes without any measures taken. In two patients the syndrome of acute occlusion of the aortic bifurcation developed. In their aortograms it was seen that the terminal part of the aorta was sharply closed. In one of them after the injection of heparin (5,000 units) the pain disappeared two hours later, and the circulation in the leg arteries was re-stored. In another patient in spite of the intravenous administration of 30,000 units of fibrinolysine together with 15,000 units of heparin acute ischemia in the lower extremities was not reduced in three hours. For this reason the patient was operated on immediately. During the operation severe atherosclerosis of the abdominal aorta and the iliac arteries with the occlusion of the right external iliac artery and the stenosis of the left common iliac artery was revealed. When opening the aorta, it turned out that the tunica intima had been pushed off from the aortic wall up to the level of bifurcation. In both common iliac arteries there was a fresh thrombosis. The tunica intima torn from the aortic wall was re-

moved and the bifurcation bypass to both femoral arteries was performed. After the operation the circulation was completely restored. The postoperative course was uneventful.

The injection of the contrast medium into the aortic branches was performed in 10 cases.

Table 3

The artery where contrast medium was injected	Number of patients
1. Superior mesenteric artery	1
2. Renal artery	4
3. Inferior mesenteric artery	2
4. Lumbar artery	3
T o t a l: 10	

In one patient 25 cm³ of 70 per cent diodone solution was injected into the superior mesenteric artery. The patient immediately felt severe pain in his stomach. An X-ray investigation seven minutes later demonstrated that the contrast medium was still in the artery. One hour later the roentgenogram did not show any traces of the contrast medium, the pain disappeared without further disturbances.

In 4 patients 20 to 25 cm³ of 70 per cent diodone solution was injected into the renal artery. No disturbances followed.

In 2 patients 20 cm³ of contrast medium was injected into the inferior mesenteric artery and in 3 patients into one of the lumbar arteries without any complications.

Consequently, contrary to the data in the literature, /D.E. Szillagyi et al., (3); R. Gottlob et al., (4)/ we had no complications, like aneurysma dissecans, bowel necrosis and gangrene of the lower extremities.

One of our patients with stenocardia at rest died during aortographic investigation as a result of myocardial infarction. The infarction developed immediately after the injection of the contrast medium.

In one patient four hours after translumbar aortography paralysis of the right side of the body developed and remained. A thrombosis of the left cerebral medial artery was diagnosed.

In 267 patients the following complications occurred after transfemoral catheter aortography.

Table 4

Complication	Number
1. Thromboses of the femoral artery	6
2. Massive hematoma formation from the puncture	1
Total 7	

The thrombosis of the femoral artery upon insertion of the catheter occurred in 6 patients. 3 of these patients suffered from an atherosclerotic lesion of the iliac and femoral arteries, whereas systolic murmur was not auscultative on the femoral artery being punctured. In one of these three patients we could not insert the catheter higher than the aortic bifurcation due to its atherosclerotic lesion.

Blood flow from the puncture of the femoral artery after abdominal aortography by the Seldinger method occurred in one patient with hypertension (RR - 240/120 mm Hg). To do away with the blood flow, we had to suture the puncture wound of the femoral artery. The patient recovered without complications.

In 4 patients blood flow in the lower extremity had

to be surgically restored by removing the thrombus from the femoral artery. In only one of these the femoral artery was not sclerotic, as it turned out during the operation. The results of the operations were good in all patients.

In 2 patients we could eliminate the thrombosis and restore the blood supply in the lower extremities by means of conservative therapy (fibrinolysin with heparin).

In 3 patients the investigation failed, as we could not insert the catheter into the aorta due to the sclerotic twisting of the iliac arteries.

Thus we had 7 complications for 267 cases of aortography by the Seldinger method.

We have not noticed the occurrence of other severer complications often referred to in the literature /H. Th. Saur, (5)/.

As the amount of contrast ^{aine} medium used by us was small (20 to 25 cm³), we did not note any complications caused by the toxic effect of contrast media on parenchymatous organs in case of thoracic and abdominal aortographies.

According to the literature /F. Morino et al., (6), etc./ and our own data, we can conclude that retrograde catheter aortography after Seldinger cannot be applied to patients suffering from obliterative atherosclerosis in the lower extremities. It is indicated for the visualisation of renal and other branches of the aorta, for the diagnosis of abdominal tumours and other diseases, but also for thoracic aortography and coronarography in patients whose iliac and common femoral arteries are unchanged.

Considering correct indications and counterindications, translumbar aortography and retrograde catheter aortography after Seldinger can be successfully applied for the diagnosis of various arterial diseases.

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Significance of Phlebography and Endovascular Electrocoagulation in the Operative Treatment of Varicosis of the Lower Extremities

B. Pöder, E. Tünder, K. Pöder, H. Tikko, P. Roosaar

Varicosis of the lower extremities is a widespread disease with a progressive course from which 10 to 30 per cent of the adult population suffers in different countries (1, 2, 3, 4, 5). In spite of numerous papers on varicosis the problems of its diagnosis and the choice of operative methods have not yet been thoroughly elaborated. Having applied different operative and occlusive methods, recurrence occurs in 10 - 50 per cent of patients (6, 7, 8, 9, 10). The recurrence of varicosis and its complications often lead to a considerable drop of the capacity of patients and even to their disability /11/. Proceeding from the above data, it is evident that exact diagnosis of different pathological conditions of the venous system in the lower extremities is of essential significance for determining rational therapy. In addition to generally applied functional tests we believe that in patients with stasis ulcers, postthrombotic syndrome, trophic changes of the skin, oedema in the extremities, etc., it is necessary to perform phlebography. Only so we can evaluate the variations of the venous system, in case of pathology its location and extent, the condition of collateral circulation and the communications between the deep and superficial venous systems.

Material and Methods. Since 1963 the authors have made 220 phlebographic investigations in 208 lower extremities. Intravenous centripetal phlebography was applied in 167 and intraosseal in 53 cases. In the intraosseal method, contrast medium was administered into the spongy substance of the heel, thigh or shin bones by a special needle trocar. In

intravenous administration of contrast medium it was injected into the great saphenous vein in the region of the ankle or into the veins at the back of the foot. Most of the vasographic investigations were performed with the patient in a horizontal posture or at an angle of 45°. As the contrasting of deep veins in the lower extremities depends on the general amount of superficial veins, we have emptied the superficial veins (before injecting the contrast medium) by elevating the extremity or by placing an elastic bandage on the calf. To avoid venospasm and venous thrombosis, 15 to 20 ml of 0.5 per cent procaine solution together with 5,000 units of heparin were injected intravenously. After the exposure the patient was made to produce active movements with the extremity and short-term massage was applied to reduce the possible sedimentation of the contrast medium in the venous valves. As contrast media we used mainly 30 to 50 per cent hypaque or diodone solution (20 to 40 ml.). The classification elaborated by J. Berndt /12/ was used while analysing the phlebograms.

In choosing operation methods for varicosis in the lower extremities it is essential that the method should give good follow-up results, cause minimum trauma, and have a favourable cosmetic effect. As the generally applied operation methods only partly meet these requirements, we have used the method of endovascular electrocoagulation since 1965. By this method 108 patients (male 37, female 71, average age 45) have been operated on, 97 per cent of them having various complaints due to varicosis (cramps, pain and fatigue of the legs, oedema, skin itching, etc.). The operation was usually performed under general anesthesia (in 99 patients). Endovascular electrocoagulation was performed using probes with either mono- or biactive electrodes connected to an ordinary diathermia apparatus. After the surgical exposure of the varicose vein a probe was inserted into the venous segment to be coagulated. With the switching-on of the current

the retraction of the electric probe began at an approximate speed of 2 cm/sec., the venous segment under coagulation being simultaneously compressed by hand for maximum contact between the venous wall and the electrode. Both ortho- and retrograde intravenous electrocoagulations were applied, whereas total coagulation of the long saphenous vein was performed in 92 patients and a partial one in 16 patients with varicosis. In most cases endovascular electrocoagulation was combined with other operative methods (excision of the varicose veins, saphenous vein ligation at groin, insertion of percutaneous ligatures, and subfascial ligation of the communicating veins). After the operation an elastic dressing was applied from toe to groin and the extremity was placed on a Braun splint. The patients were allowed to walk on the first postoperative day contrary to a number of investigators /13, 14/ who allow their patients to get up on the 4th to 6th day. No complications occurred due to early ambulation. It is advisable to wear an elastic compression dressing for 4 months, as this is conducive to the obliteration of the coagulated veins and accelerates centripetal venous blood circulation.

Experimental Methods. To find out the reasons for recurrence and complications, analogous operations were performed on the superficial veins of both hind legs in 20 dogs. The experiments lasted for 2 to 50 days.

Results. In analysing phlebograms the classification of pathology in the venous system of the lower extremities presented by J. Berndt was used. This comprises five main types, considering pathological changes in the superficial, deep and communicating veins.

I. Intact deep and communicating veins; varicose changes in the superficial venous system - 74 cases.

II. Intact deep veins; pronounced varicosis of the superficial veins combined with the insufficiency of the communicating veins - 49 cases.

III. Varicose changes in all the three venous systems

- 13 cases.

IV. Thrombosis in the deep veins combined with secondary varicosis of the superficial system - 20 cases.

V. Recanalized deep veins with damaged valves and secondary varicosis of the superficial and communicating veins - 37 cases.

Pathological changes occurred in 193 phlebograms. The remaining 8 phlebograms were normal.

Complications developing as a result of intravenous phlebography were mainly slight in character and passed without any particular treatment. In case of intraosseal phlebography under local anaesthesia pain reaction was often quite severe and subfebrile temperature lasted for 1 to 2 days. The analysis showed us that there were considerably fewer complications in case contrast media of lower concentration (30 per cent) were injected, anticoagulants were locally intravenously administered, the extremity was bandaged by means of an elastic dressing and active movements were performed with the extremity after phlebography.

— During the introduction of the method of endovascular electrocoagulation, complications occurred in a few cases, such as skin burns of the 1st or 2nd degree. In later operations these complications were avoided by the infiltration of paravenous tissue with a 0.5 per cent solution of procaine. The follow-up of 84 patients revealed that operative results were not satisfactory in 3 of them due to the recurrence of varicosis.

Animal experiments and histological investigations revealed that in the obliteration of an endovascularly coagulated vein the thrombus in the lumen and its organization is of decisive importance. If there was no thrombus in the venous lumen and the lumen had preserved a circular cross-section, venous obliteration was not noted. Extensive lesions of perivascular tissue obviously limited

chances for obliteration, because crimped cicatricial tissue prevented the venous walls from contraction. Extensive lesions of perivasal tissues led to complications, such as lesions of smaller arteries and nerves. Injury to the venous wall due to endovascular electrocoagulation is usually so extensive that the vein perishes either because of electricity or as a result of later tissue reactions. The coagulated vein is practically completely obliterated for 4 to 5 weeks after the operation. Later tissue reactions do not determine the surgical results. Recanalisation of obliterated veins was not noted.

Conclusions.

1. Phlebography is a necessary research method first of all for the diagnosis of complicated varicosis of the lower extremities and the postthrombotic syndrome.

2. Endovascular electrocoagulation of the vein combined with other surgical techniques is a suitable method for the treatment of patients with varicosis of the lower extremities because of its simplicity, few complications and recurrences, good cosmetic results and a short period of hospitalisation.

3. Venous obliteration is caused by the development and organisation of a thrombus in the venous lumen after the electrocoagulation and the approximation of venous walls guaranteed by the application of external compression in the form of an elastic bandage or stocking during four postoperative weeks.

4. Relapses and complications may be due to too intensive thermic lesions leading to severe lesions of the tissues surrounding the vein.

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Evaluation of Hemodynamics in the Venous System of the Lower Extremity

J. Männiste

Venous obliteration, dilatation and valve insufficiency in the superficial, and especially in the deep venous system of the lower extremities lead to hemodynamic disturbances expressed as the re-distribution of the blood amount flowing through the superficial and deep systems and as venous stasis in one or both systems. Nine-tenths of the outflow from the extremity normally takes place via the deep system /N.N. Elanski (1), K. Holzegel (2)/.

Hemodynamic balance is based on the equality of the blood amounts flowing in and out of the extremity in a time unit. There is undoubtedly no hemodynamic balance in the acute stages of venous occlusions, but in case of chronic venous insufficiency syndrome, stability is established which can fail only while loading the extremity or changing the posture. In the overburdening case of insufficiency of the deep system, the overburdening of the superficial system causes venous stasis in it, although the amount of blood outflow from the extremity is not reduced.

The stability of hemodynamics in case of venous dilatation is sometimes guaranteed by the lower blood flow speed, because it is inversely proportional to the square of the blood vessel diameter /J. Nielubowicz (3)/. Venous occlusions which cause the formation of new collaterals, the re-distribution of the load between the superficial and deep systems, changes in the diameter of veins, venous backflow into the periphery due to valve lesions and changes in blood flow speed between the different parts of the venous system play the most important role in the evaluation of hemodynamics and they are also basic criteria

in the choice of operative methods. With most patients hemodynamic disturbances occur in the vertical posture.

We have used the vertical fluorophlebographic method with the widetrack (70 x 70 mm) fluorograph TUR since September, 1965, for the better evaluation of the functional state of the venous system.

The patient stands in front of the screen on a dais, his body being supported by the healthy leg. 20 ml of 0.25 per cent procaine solution together with 1000 units of heparin are injected into a small dorsal vein of the foot to prevent venous spasm, 30 to 40 ml of urographin or diodone solution is used as contrast medium. Before each exposure the extremity under investigation is loaded imitating a step. The 1st and 2nd exposures are made from the calf, the 3rd to 5th exposures from the thigh, the 6th to 10th exposures are again made from the calf. The interval between the exposures is of little importance because the flow of contrast medium is mainly carried out by muscular contractions. Exposure conditions for the calf: 40 to 45 m/A per sec., 75 kW; for the thigh: 45 to 50 m/A per sec., 80 kW.

Fluorophlebograms were contrasting enough and their interpretation was usually not difficult. Most of the 96 investigations were carried out in the outpatient clinic. No complications occurred.

Injected into the superficial dorsal vein of the foot one part of the contrast medium is carried directly and another part via the vv. communicantes into the deep system /Halse (1)/. In the patient's veins the contrast medium is removed from the extremity by the 5th to 6th step (determined empirically in 11 patients with normal veins).

Evaluating hemodynamic venous insufficiency, we followed the residual occurrence of contrast medium in one or another part of the venous system.

In the case of dilatation or valve insufficiency of

the deep veins of the extremity a portion of the contrast medium is forced in the direction of the heart by muscular contractions, but a portion of it flows distally. With the insufficiency of the communicating veins the contrast medium unnaturally moves into the superficial system, from where it partly flows into the deep veins again during relaxation. A pendulous movement of the blood is developed and the contrast medium remains in the leg in the vertical posture for longer than 10 steps.

The retention of the contrast medium after the 6th to 10th steps in various parts of the venous system is classified by us into the I-II-III stages of venous insufficiency.

The syndrome of the first-stage venous insufficiency (25 patients with varicosis, thrombophlebitis or postphlebotic syndrome) comprised the patients with whom contrast medium retention occurred in the superficial system only. The anatomical basis for the first-stage venous insufficiency is superficial varicosis and valve insufficiency, the partial occlusion of the superficial system or backflow via the communicating veins.

In the second-stage venous insufficiency (24 patients with postthrombotic syndrome or deep thrombophlebitis) the contrast medium was observed in the deep veins only, whereas the superficial system was completely unchanged and emptied. In superficial thrombophlebitis where the regions of the communicating veins were occluded and also in case of the surgical extirpation of the superficial system or where insufficiency in the deep system is present, we observed residual contrast medium in the deep system only. In the case of occluded deep veins of the calf their collateral circulation may be compensated by muscular veins without the occurrence of residual contrast medium, but in most cases the insufficiency recurs very soon owing to the reflux via muscular veins. The second-stage venous insufficiency was also observed in 5 patients with primary lymphoedema.

The third-stage venous insufficiency (in 47 patients with postthrombotic, postphlebitic syndrome or varicosis) shows the retention of residual contrast medium in both the superficial and deep systems. It is anatomically based on the above-described lesions combined in both systems. The late stage of thrombosis usually ends in the third stage of venous insufficiency.

Fluorophlebographic investigation characterizes hemodynamic insufficiency more exactly, because the functional changes due to the action of hydrostatic pressure on peripheral veins are well reflected.

Many attempts have been made to characterize hemodynamic changes. I. Prerovsky et al. (5), N.N. Elansky (1), A.F. Harhuta (6) determined the time for venous outflow by the intravenous lobeline or nicotine acid test, but Th. Halse (4) and V. Stancanelli (7) radiocirculographically, tried to determine venous stasis.

Proceeding from the methods applied by the above-mentioned authors, we checked changes in the blood flow rate in the third- and first-stage venous insufficiency syndromes, during the walk and horizontal posture of the patient. Nicotine potassium, injected into the dorsal vein of the foot, behaves like a contrast medium there. A hot feeling in the face and hyperemia develop when the nicotine potassium has passed the extremity veins and v. cava inferior, the heart, pulmonary circulation, vasomotor centres leading to excitation and reaction of skin capillaries. The time necessary for the drug to reach the reaction region is recorded. The extent of this period undoubtedly depends on the time required for passing the venous system of the lower extremity, but in addition it depends on many other factors which make the test extremely indirect. To check the time for blood flow, we also injected nicotine potassium into the femoral artery, this being practically an injection immediately into the deep system. The lengthening of the passage

for the drug by the arterial part of the extremity is comparatively short and does not change the results of the experiment essentially.

In the third-stage insufficiency the time of subjective reaction in the horizontal posture was $\bar{X}_1 = 112'' \pm 8$, $n = 24$; in walking $\bar{X}_2 = 105'' \pm 6$, $n = 10$; in intraarterial injection $\bar{X}_3 = 84'' \pm 5$, $n = 24$. In the first-stage insufficiency $\bar{X}_1 = 77'' \pm 5$, $n = 10$; $\bar{X}_2 = 63'' \pm 2$, $n = 10$; $\bar{X}_3 = 60'' \pm 2$, $n = 10$. In normal veins (the 0-stage) $\bar{X}_1 = 57$, $\bar{X}_2 = 60$ and $\bar{X}_3 = 57''$.

It is evident that in the case of third-stage venous insufficiency reaction time both in the horizontal posture and following walk was lengthened, compared with the 0-stage or the first-stage venous insufficiency. With the intraarterial injection time limits do not essentially differ in cases where the disturbances of deep veins were absent. In the third-stage insufficiency the distribution of the drug is in favour of the superficial system as one with larger venous stasis even in the horizontal posture, thus delaying the arrival of an effective amount of it into the reaction region. In general, in intraarterial injection the periods are shorter, because a portion of the drug gets into the v. cava inferior system from the basin of the a. femoris profunda through the thigh and pelvic collateral veins. In the third stage of venous insufficiency under walking conditions an effective amount of the drug enters the deep system from the superficial one more rapidly, compared with a horizontal posture.

We are of the opinion that the determination of the blood flow rate by the nicotine acid or lobeline tests is very indirect and does not exactly characterize venous hemodynamics in the lower extremities.

They may be of use in determining the indications

for roentgenovasographic investigations and may also be applied in cases when contrast medium is not tolerated.

Conclusions

1. The vertical functional fluorophlebographic method makes it possible to observe visually residual contrast medium in different parts of the veins of the lower extremities and determine a functional venous insufficiency.

2. Residual contrast medium in the superficial system only (Stage I) is a characteristic of intact deep veins if the deep system is filled in the first exposures. The syndrome of the second-stage venous insufficiency indicates that the superficial system is intact and venous stasis present in the deep system. The syndrome of the third-stage venous insufficiency demonstrates both superficial and deep venous insufficiency.

3. The determination of the blood flow rate via the venous network of the systemic circulation by drugs, giving subjective or visual reactions, is an indirect method, but it makes it possible to differentiate the first- and the third-stage venous insufficiency.

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Homo-Allografting of the Abdominal Aorta
(Experimental Investigation)

K. Pöder, P. Roosaar

Experimental and clinical observations show us that the present-day allografts used do not completely meet the requirements for vascular operations. The occlusion of these grafts is too frequent. That is why the search continues for more perfect grafts. In the present experimental paper a new idea is applied following Academician A.N. Filatov's suggestion that the inner layer of allografts should be produced out of biological material - a homovein.

Experiments were carried out in 58 adult mongrel dogs. 24 dogs were used as donors. In 48 animals a segment of the abdominal aorta was replaced by a graft, in 10 dogs by-passing of the aorta bifurcation was performed by a homo-allograft. To produce combined homo-allografts a homovein conserved in A.N. Filatov solution No. 65 (composition: gelatinol 70 ml, glyose 5 g, ethyl alcohol 5 ml, formalin 2 per cent solution 20 ml) was placed in a graft made of alloplastic material. The homovein was sutured at the ends to the graft. To produce a bifurcation graft the homovein was suited to an allograft previously sutured together after J. Heinal.

The animals were clinically observed for a maximum of 400 days. For histological investigations tissue samples were taken from both anastomoses and from the central part of the graft. They were fixed in Carnoy fluid and inserted in paraffin. Paraffin section were made and painted by the survey method.

In the experiments lasting up to 30 days foreign-body reaction prevailed round the graft. Giant cells, lymphocytes and single granulocytes were found. Begin-

ning with the 8th day of experiment loose unformed connective tissue occurred beyond the allografts, reaching the pores of the allograft near the anastomoses. Subsequently the formation of the outer layers of the grafts took place, reaching sufficient sturdiness for the graft by the 30th day of experiment. The development of the medial layer takes place somewhat later. Even on the 15th day of experiment lymphocytes, few fibroblasts and young collagenous fibres were found. By the 30th day of experiment the allograft pores were filled with connective tissue. The inner layer is formed in the experiments lasting for less than 20 days by the homovein only and fibrin and thrombotic masses sedimented on it. In most cases the homovein is structureless, infiltrated with lymphocytes from the lumen. Near the anastomoses wallside thrombi occur in different degrees of organisation. In the 20-day experiments the inner layer begins to regenerate. On the one hand connective tissue regenerate of aortic origin grows on the surface of the homovein and in certain cases below it (collagenous fibres, fibrocytes, few elastic fibres), on the other hand the homovein is organised on account of connective tissue from the medial layer penetrating the pores of the allograft. In two experiments peculiar fibroblastic proliferations not connected with any of the above-described regenerates were found in the outer layer of the homovein. They may come from the single elements of the venous wall which have preserved their viability after conservation. By the 30th day of experiment a zone of endothelial cells covers the newly-formed regenerate near the anastomosis. On the contrary, in the central part of the graft there are rich necrotic masses infiltrated by lymphocytes. The vascularization of the regenerate is accomplished by the 30th day of experiment in the external and medial layers.

In the experiments lasting for 31-90 days a well-developed external layer consisting of dense unformed connective tissue was found. Vascularization was moderate.

The medial layer was formed of similar connective tissue, but contained cell elements in a greater number. Giant cells of foreign-body reaction type and lymphocytes occurred immediately round the alloplastic material. A moderate amount of fine vessels were found in the medial layer. During this experimental period constant regeneration took place in the inner layer. The regenerate of aortic origin covers the inner layer whereas the consecutive stages are distinguishable in the organisation of the homovein and thrombotic masses: intensive lymphocytic infiltration, growth of fibroblasts and fibrocytes, synthesis of collagenous fibres, later on formation of elastic fibres, formation of endotheliumlike cells and beginning with the 70th day considerable ingrowth of cells resembling those of the smooth muscle. The connective tissue regenerate proliferated through the allograft partly reached the lumen, joining the above-described proliferate. In longer experiments the inner layer often proved to be thinner than in the experiments of 30-day duration. In the experiments the vascularization of the inner layer lasted up to 90 days.

In the experiments lasting for 91-180 days intensive unformed connective tissue was found in the outer layer. A part of collagenous fibres were hyalinized. The development of the medial layer was evidently completed before three months. The finding in this region coincided with that of shorter experiments. The main feature of the development of the inner layer was a further organisation of thrombotic masses surrounded by the homovein and connective tissue. In the experiments lasting 180-400 days regenerative processes in the inner layer became inactive, due to which morphological changes stabilized. In no case was the homovein replaced by connective tissue in the central part of a homo-allograft.

In a few experiments (4 cases) lasting over 90 days there were also destructive-dystrophic processes in the

inner layer: separation of endotheliumlike cells, hyalini-
zation of collagenous fibres, ulcers, and formation of new
wallside thrombi due to ulcers. These undesirable pheno-
mena may be caused by insufficient vascularization of the
inner layer unsuitable for the massive regenerate. To
avoid that, it is obviously necessary to increase the po-
rosity of allografts. In this direction the experiments
are being continued.

Temporary Ligation of the Coronary Artery
under Conditions of Venous Stasis.

T. Sulling, R. Teesalu

Performing reconstructive operations on the coronary arteries, it is necessary to temporarily occlude the artery. The interruption of the myocardial blood supply generally leads to its fibrillation /N.A. Dzavakhishvili (1), G.R. Daicoff (2), etc./. Collateral coronary blood circulation is increased after the induction of venous stasis /C. Beck (3), and V.S. Sergiyevsky (4)/. The present paper deals with the possibilities for the temporary ligation of the coronary artery under conditions of venous stasis.

Material and Methods. To determine the outcome of the temporary ligation of the coronary artery, the ramus circumflexus of the left coronary artery was ligated in 10 dogs. Temporary ischemia in these cases lasted for 40 minutes.

In the main group of 58 experiments concurrent with the temporary ligation of the coronary artery venous stasis was induced. This was called forth by the complete ligation of the coronary sinus 15 minutes before the occlusion of the artery. Depending on the duration of the coronary artery occlusion, the main group fell into three subgroups. The first subgroup included the experiments with myocardial ischemia of 20 minutes, the second of 30 and the third of 40 minutes.

The animals were operated on under morphine-ether narcosis. The ramus circumflexus of the left coronary artery was occluded at 1 to 1.5 cm from its origin from the left coronary artery and the coronary sinus at 0.5 to 1 cm before its entering the right auricle. Depending on

the duration of the experiment either 6 or 12 hours, the dogs were sacrificed 1, 2, 5, 10 or 30 days after the operation to determine the electrolytic content and histological changes in the myocardium. During the experiment electrocardiograms were repeatedly made.

Results of Experiments. Due to the occlusion of the coronary artery without venous stasis fibrillation developed in 7 cases out of 10. In 5 experiments it occurred 2.5 to 4 minutes after the arterial ligation, but in the other 2 experiments after 7 and 17 minutes.

As to the remaining 3 experiments, in 2 dogs no fibrillation was noted during the occlusion of the coronary artery, but this complication occurred after removing the ligature. The remaining third animal survived the procedure without fibrillation, but died 18 hours after the operation.

Under the conditions of venous stasis the coronary artery was temporarily occluded in 58 experiments. In 7 cases the fibrillation of ventricles developed immediately after the occlusion of the artery. In 4 experiments it followed 3 to 6.5 minutes and in the remaining 3 experiments 26.5, 29 and 39 minutes after it, respectively. In the experiments where the coronary sinus was also ligated before the closure of the coronary artery, the danger of the development of fibrillation of the ventricles as a result of acute myocardial ischemia was considerably smaller ($p < 0.01$).

Table 1

Fibrillation of Ventricles after the Occlusion
of the Coronary Artery

	Number of Experiments	Cases with Fibrillation
Ligation of the coronary artery	10	7
Ligation of the coronary artery under conditions of venous stasis	58	7

While restoring the coronary circulation after its temporary occlusion, ventricular tachycardia developed in most experiments leading to ventricular fibrillation in 21 out of 51 animals which sustained the artery occlusion without fibrillation. Thus danger of fibrillation was definitely higher while opening the coronary artery than in consequence of its closure ($p < 0.05$). In the experiments of the first group where ischemia lasted for 20 minutes ventricular fibrillation followed the restoration of the coronary circulation in 9 out of 16 experiments. An analogous complication occurred in 5 out of 15 cases in the second group (ischemia lasted for 30 minutes). In the third experimental group where ischemia lasted for 40 minutes fibrillation developed in 7 out of 20 experiments.

Table 2.

Ventricular Fibrillation after Restoring the
Coronary Circulation in Ischemic Area

	Duration of ischemia in minutes	Number of experiments	Cases with fibrillation
Subgroup 1	20	16	9
Subgroup 2	30	15	5
Subgroup 3	40	20	7
T o t a l		51	21

Judging by Table 2, the development of fibrillation under the conditions of venous stasis does not depend on the duration of the coronary occlusion ranging from 20 to 40 minutes.

In the experiments with ventricular fibrillation defibrillation was applied in 15 cases, 11 of them being successful. It was characteristic that immediately after the removal of the ligature from the coronary artery defibrillation failed, but it was successful in most cases

after a heart massage of 5 to 30 minutes duration.

41 animals without ventricular fibrillation neither while occluding nor restoring the coronary circulation were left for a long-term follow-up. 13 of them died during the follow-up period lasting up to 10 days. In 10 animals ischemia lasted for 40 minutes, in 2 animals for 30 minutes and in only 1 animal for 20 minutes. In the group with ischemia with a duration of 40 minutes the number of fatal cases was thus considerably greater than in the other groups.

Table 3.

Experiments Leading to Death

	Duration of ischemia in minutes	Number of experiments	Fatal cases
Subgroup 1	20	11	1
Subgroup 2	30	11	2
Subgroup 3	40	19	10
T o t a l		41	13

During the first 24 postoperative hours 11 out of 13 animals died. In 2 animals ventricular fibrillation due to a technical error (casual touch with a clamp against the ischemic myocardium was immediately followed by fibrillation) developed before suturing the thorax. One of the dogs died of pneumothorax. The remaining 8 animals died of causes which could not even be ascertained at the autopsy. 6 animals died suddenly in spite of a comparatively uneventful postoperative course. During the later follow-up period 2 animals died of empyema.

Morphological findings revealed that myocardial infarction did not develop in a 20-minute ischemic period under conditions of venous stasis. 30 and 40 minutes of ischemia led to necrotic foci in the ischemic myocardium.

Discussion. In the experiments performed by C. Beck (3) and V.S. Sergiyevesky (4) the protective effect of venous stasis after occluding the coronary artery appeared in the 3rd or 4th postoperative week only. By that time new collateral vessels might develop. During the earlier postoperative period after the occlusion of the coronary artery ventricular fibrillation occurred as frequently as in the experiments without venous stasis. Contrary data are reported by D.S. Zubov (5) and T. Gitescu (6).

In our series ventricular fibrillation appeared considerably less frequently if venous stasis was called forth 15 minutes before the arterial occlusion. Our results differ from those obtained by most investigators, obviously due to the following circumstances.

First, in our experiments the coronary sinus was completely occluded, whereas the other investigators only constricted it. The fact whether the coronary sinus is partly or completely closed is of great importance, because there is considerably more collateral circulation in case of a complete sinus ligation than in a partial one (7). Thus in our experiments the death rate after the ligation of the coronary artery was reduced because of the complete sinus closure.

Secondly, in our series of experiments ischemia together with the preceding sinus ligation was temporary and comparatively short. That is why the compensatory mechanism could preserve myocardial contractility.

According to the data in the literature the causes of the development of fibrillation while removing the ligation from the coronary artery are obscure. We think that fibrillation is called forth by the harmful action of blood flow restoration in the ischemic region of the myocardium.

According to Jennings et al. (10, 14) in the temporary ligation of the coronary artery the signs of myocardial damage develop considerably more rapidly than when

there is the permanent ligation of the same artery. Due to ischemia, myocardial tolerance against various harmful factors is reduced and after the restoration of circulation extensive changes in myocardial metabolism develop, esp. K^+ increase in the extracellular space, which may precipitate myocardial fibrillation.

In the experiments performed by R.B. Jennings et al. (10), P.B. Herdson et al. (11) and S.A. Vinogradov (12) the myocardium had undergone severer lesions upon the temporary occlusion of the coronary artery than in case of its permanent ligation. The same was proved by our experiments: in the ischemic myocardial region intensive blood extravasations occurred and even infarcted foci appeared due to an ischemia of 30 and 40 minutes.

Immediately after the development of fibrillation defibrillation failed in all the experiments, apparently as a result of extensive hypoxia of the heart muscle. Defibrillation was successful only after cardiac massage and the administration of medicaments which served to abolish severe myocardial hypoxia. The other investigators (4, 13) also refer to difficulties connected with the defibrillation of a hypoxic heart.

Sudden death in the early postoperative period was obviously caused by ventricular fibrillation due to myocardial lesions as a result of long-term (40 minutes) ischemia and defibrillation. Also R.B. Jennings et al. (14) and R. Pifarre (15) indicate that ventricular fibrillation is most frequent 10 minutes and 4 to 8 hours after the ligation of the coronary artery, because the reduction of intercellular K^+ is most intensive then.

It is advisable to call forth venous stasis in reconstructive operations on the coronary arteries because this makes it possible to occlude the coronary artery for a longer period of time.

Conclusions.

1. If before the temporary ligation of the coronary artery venous stasis by temporary complete ligation of the coronary sinus is called forth, the danger of myocardial fibrillation is considerably reduced.

2. The reconstruction of blood flow in the occluded coronary artery under conditions of venous stasis leads to cardiac rhythm disturbances, ending in part of the experiments with ventricular fibrillation.

3. Under conditions of venous stasis the temporary ligation of the coronary artery for a duration of 20 minutes does not cause myocardial necrosis. Infarcted centres develop in the myocardium as a result of 30- and 40-minute ischemia.

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Blood Vessel Allografts in Experiment and Clinical Practice

E. Sepp

Obliterative atherosclerosis comprises the majority of vascular diseases. This disease is expressed by comparatively poor prognosis in the abdominal aorta, the iliac and lower extremity arteries, often leading to the patient's death or life-time invalidity in uncorrected cases.

In atherosclerosis the diffuse lesions of blood vessels are mainly noted in the advanced stages of the disease; segmental stenoses or occlusions mainly occur in the initial period of the illness, making it possible by means of surgical intervention to normalize blood flow.

Various methods of treatment have been applied in the reconstructive surgery of blood vessels to restore the arterial blood flow.

Experimental and clinical studies have shown that allografting can be a satisfactory method for treating atherosclerotic lesions in the aorta and the main arteries.

It has been established that the effect of the operative therapy of blood vessels greatly depends on the material of allografts and its numerous other properties, such as porosity, elasticity, wall thickness, etc.

At the present time allografts of different physico-chemical and biological properties are produced, but it has not yet been fully explained which of them are preferable, although operative results considerably depend on the properties of allografts.

The application of different vascular prostheses revealed their different properties and led to their more detailed studies.

The aim of the present investigation is the following:

(1) comparison of macroscopic and histological changes in various prostheses both in experiment and clinic;

(2) which of the prostheses under investigation is to be recommended for vascular reconstructive surgery.

In 67 dogs 116 transplantations in the thoracic or the abdominal aorta were performed with 10 different types of vascular allografts.

Porous crimped vascular allografts made by the Leningrad Textile Factories "Krasnoye Znamya" and Lentotkatskaya Fabrika No 2" and the Kaunas Textile Factory "Kaspinas" (Lithuanian SSR) were employed.

Vascular prostheses produced at the textile factory "Krasnoye Znamya" were made of the following materials:

(1) terylene (1962) - knitted; (2) terylene (1963) - knitted.

Prostheses produced at the textile factory "Lentotkatskaya Fabrika No 2" in 1963 were made of the following materials: (1) lavsan - woven; (2) phtorlon - woven; (3) lavsan-phtorlon - woven; (4) lavsan - plaited.

The following prostheses were produced at the Textile Factory "Kaspinas" in 1963: (1) lavsan - woven; (2) phtorlon - woven; (3) lavsan-phtorlon - woven; (4) lavsan-polypropylene - woven.

The diameter of prostheses ranged from 6 to 12 mm and their length from 1 to 14 cm.

96 out of 116 experimental grafts remained patent during the observation period lasting from 10 minutes to 1009 days. When a vascular allograft was substituted for a thoracic segment of the aorta, 3 out of 57 grafts (5.2 per cent) thrombosed. When a vascular graft was substituted for the abdominal aortic segment, 13 out of 54 grafts (24.07 per cent) thrombosed. 4 out of 5 vascular grafts thrombosed while acting as substitutes for the main arteries.

The comparison of various grafts showed that a greater number of thromboses occurred while applying phtorlon

woven vascular prostheses produced at the Kaspinas Textile Factory and while applying lavsan plaited and woven vascular prostheses manufactured at the "Lentotkatskaya Fabrika No 2".

The thickness of a graft intima in the hollows ranged from 0.27 to 3 mm, on the peaks of the crimpage from 0 to 2 mm.

The study of the changes in the thickness of the graft intima in connection with the observation time showed that in various grafts the inner layer undergoes essentially the same changes.

Immediately after the restoration of blood flow through the allograft, a fibrinous layer developed on the inner surface of the prostheses with a thickness of up to 3 mm. With the prolongation of the observation period, due to the organisation processes proceeding in the inner layer of the graft, it began to grow thinner. The inner layer of the graft was thinnest in the experiments with an observation period of 3 to 4 months. In longer experimental periods the inner layer began getting thicker, reaching its maximum thickness on the average in 8 to 9 months. With a further prolongation of the observation period the inner layer became gradually thinner.

The grafts which had functioned in the organism of the experimental animal from 10 minutes to 678 days were studied histologically.

The organisation of the deposited fibrin took place mainly in two places - at the ends of the resected blood vessels of the recipient and in the tissues surrounding the prosthesis. As the histological pattern of the graft revealed, the organisation of fibrin in prostheses with a comparatively small permeability mainly took place at the ends of the resected aorta of the recipient. In our experiments intimal thickenings were noticed already within an observation period of 15 days. Such reactive intimal pads were formed from fibroblastlike cells and colla-

genous fibres, but beginning with the second postoperative month smooth muscle cells and elastic fibres developed. Most intimal pads were covered with endothelial cells. All the elements making up the intimal pad grew from it towards the centre of the grafts.

The organisation of fibrin proceeded slowly. The longer the graft, the longer the period for the organisation of fibrin in the middle of the graft.

On the average two months after the vascular plastic operation a layer of endothelial cells was noted at the ends of the allograft. Fibroblasts were observed at the ends of the graft intima already at the end of the first postoperative week. Their amount increased with the longer period for graft observation, whereas the amount of fibroblasts in all the artificial grafts applied was considerably larger at their ends than in their centre, where the first fibroblasts were noted two months after transplantation. Due to the slow organisation process of fibrin, in all the grafts more fibrin occurred in their centre than at their ends.

As a result of the organisation processes of the graft, inner layer smooth muscle cells and elastic fibres appeared on the lumen side of the inner layer of a graft.

The longer the observation period of the graft, the larger the amount of smooth muscle cells and elastic fibres. 1.5 months after the transplantation, smooth muscle cells and elastic fibres were first noted in the vicinity of anastomoses. However, when the observation period was longer, numerous smooth muscle cells and elastic fibres could be observed only in the central portion of grafts of great porosity (knitted terylene prostheses). Thus, 6 months after the transplantation smooth muscle cells and elastic fibres were observed in the middle of the grafts made of terylene, when prostheses of great water permeability were used.

The inner surface of the graft was fully covered with endothelial cells only in the grafts during a longer observation period. As a rule, endothelial cells were found

on the inner layer only near the anastomosis of the graft.

In the organisation process of the inner layer of the graft vasa vasorum were noticeable near anastomoses already two months after the transplantation. Their amount increased together with the length of the observation period of the graft. In the central part of the graft they could be noticed in experiments with a considerably longer observation period, whereas vasa vasorum were noticeable in the inner layer of vascular protheses of greater permeability after the lapse of a shorter observation period.

In most cases vasa vasorum were noticed in the hollow of the graft crimpage. In case of longer observation periods vasa vasorum were noticed also in the lumen portion of the graft intima. Their growth was clearly seen from the outer graft layer through the pores in the graft wall. In the experiments where the outer layer of the graft contained much fibrin, there was a considerable deceleration in the organisation of the inner layer of the graft.

As a sign of early complications, liquefaction of fibrin could be observed in places in the graft intima, occurring comparatively more in the lumen portion of the graft. In places liquefaction of fibrin occurred immediately below the endothelial cover. This may result in the detachment of the endothelium and the origin of wallside thromboses, which may end in the thrombosis of the graft. When fibrin was surrounded by a dense connective tissue rich in collagenous fibres, it remained unchanged even for years without showing any liquefaction of fibrin nor any preliminary organisation of fibrin.

In numerous graft intimas hyalinisation of collagenous fibres was noticed. This occurred in protheses irrespective of the kind of the artificial fibres used. Hyalinisation of collagenous fibres was mainly noted in grafts with a five-month or longer observation period. The degree of the hyalinisation of collagenous fibres did not increase essentially together with the prolongation of the observation period.

The formation of calcificates occurred in places between hyalinised collagenous fibres.

Adipose and myeloid tissues (occurring already five months after an operation) were noticed in the dense connective tissue of entangled fibres in the crimpage hollows opposite the graft tissue. In the graft intima, in the region between the smooth muscle cells and elastic fibre layer and the underlying granulation layer osseous metaplasia was noted. There connective tissue cells had changed into osteocytes and osseous basic substance had formed between them. Such osseous metaplasia occurred in the grafts already after an observation period of one and a half months, but mostly three months after the operation.

The study of the results of vascular alloplastics in experiment as well as in clinic showed that there were great qualitative and quantitative differences in the organisation processes occurring round the graft tissue. Both in experiment and in man organisation processes in a graft began in the vascular intima, adventitia and tissues of the recipient, all of which had formed a lodge for a vascular allograft. Organisation processes in man were very slow. When in experiment fibroblasts were first noted in the graft intima at the end of the first postoperative week, in man they were noted not until the lapse of four months.

In the grafts which had functioned in man, fibrin remained essentially unchanged in the intima for a very long period of time (2.5 years), even without the liquefaction of fibrin. Due to that fact, the inner layer of patent grafts was extremely uneven and covered with numerous wall-side thrombi.

In the intima of grafts which had functioned in man and in intimal pads, neither the formation of smooth muscle cells nor elastic tissues was noticed.

The organisation of the external layer of the graft was usually completed in man in 3 to 3.5 months after the operation, matching with the results of alloplastics in ex-

periment. Further growth of the connective tissue through the pores of the graft wall was considerably slower in man. ^{Some of the} While in experiment there was moderate infiltration of mononuclear cells round the graft fibres without special inflammatory phenomena in most cases, in man there were numerous ^{foreign-body} giant cells round the graft fibres in addition to the abundant infiltration of mononuclear cells, which is one of the specific distinctions of connective tissue reactivity. Tissues round the graft reacted to more intensive inflammatory phenomena. Only in cases where knitted terylene grafts with good permeability were applied, the reaction of foreign-body giant cells round the graft fibres was considerably weaker and the organisation of the graft intima was considerably better than in the rest of the grafts with twenty times smaller average permeability. ^{Consequently,} the higher the permeability of vascular allografts, the better the organisation processes in the graft intima.

The external layer of allografts applied in the clinics may be regarded as two separate layers, where the portion of the external layer beyond the crimpage peak level was uniformly formed both in man and in experiment. The other portion of the graft external layer in the crimpage hollows was formed in man in a different way. There occurred typical signs of aseptic inflammation, which were not noted in experiment.

Judging by the results of all the work groups under study, morphological changes round the allograft tissue are essentially of the same kind. The graft tissue was like a frame round which the so-called new blood vessel was formed by the recipient tissues, but the results of vascular plastics must not be applied to man without any modifications, because the organisation processes of grafts were in man considerably slower. While the basic organisation processes of the graft external layers ended simultaneously in experiment as well as in man, the organisation

process of the graft intima was very slow in man, since the low permeability of most vascular allografts and a comparatively thick layer of the granulation tissue round the graft tissue hindered the ingrowth of the connective tissue in the graft intima. Due to that, the graft intima was mainly formed of fibrin loosely connected with the graft tissue. Such insufficient structure of the graft intima in man may easily lead to the detachment of the intima and the thrombosis of the grafts.

Summing up the results of the present investigation, allografts made of lavsan fibres under observation of the technique of woven lavsan grafts produced at the textile factory "Kaspinas" can be recommended for vascular plastic surgery. However, the permeability of these allografts should be higher. To obtain better operative results in clinics, considerably higher biological inertness of graft materials guaranteeing a more perfect structure of the graft intima would be necessary in addition to the increased permeability of allografts.

Changes in Water and Salt Metabolism after Aortic Operations

R. Talvik

The results of surgical operations do not depend only on technically perfect operation. Correct therapy in the postoperative period is quite often of great importance. Surgical interference calls forth a number of changes in the homeostasis of the organism, the extent of which depends on the trauma of the operation, the preoperative condition of the organism and a number of other factors which cannot always be precisely estimated. The more extensive the operation, the more intensive disturbances there are in metabolism and the more careful must be the postoperative treatment.

The principles of postoperative therapy have often been changed. Nowadays one of the main rules is to control water and electrolytic metabolism. We have not found any papers dealing with water and salt balance in vascular operations.

Material and Methods. In the present paper 100 individuals were studied. 20 of them were practically healthy (control group), in 45 the Leriche syndrome was diagnosed, in 29 aortic coarctation, and in 6 patients an aneurysm of the abdominal aorta was found. 60 patients were repeatedly investigated during the postoperative period. In 26 patients aortic coarctation was substituted for an allograft, alloplastic grafting on the aortic bifurcation and main leg arteries was performed in 15, and uni- or bilateral lumbar sympathectomy was done in 19 patients.

To evaluate water and electrolytic metabolism, the concentrations of sodium, potassium and chloride in the plasma, in erythrocytes and in the urine were determined. Also the water content of the plasma and erythrocytes and the acid-base balance in blood was estimated. The concentration of potassium and sodium was determined by means of a flame pho-

tometer Zeiss III, of chloride after Schales and Schales, of water by heating at 100° for 48 hours and the acid-base balance by means of the micro-Astrup apparatus and Siggaard-Andersen nomograms. The plasma and electrolytes were separated by a centrifuge with 1,500 g for 30 min. Under such conditions the trapped plasma remains within the limits of 2 to 5 per cent /Jackson et al., (1); Leeson et al., (2); Riecker et al., (3)/. All these values were determined before and after the operation on the 1st, 2nd, 3rd, 7th and 14th day.

Results and Discussion. In patients with the Leriche syndrome the potassium concentration in erythrocytes was elevated before the operation, there was also a trend to metabolic acidosis in the blood.

In patients with aortic coarctation a trend for an increased potassium concentration in the plasma was noted. It was impossible to ascertain a significant correlation between the sodium concentration in the plasma and systolic arterial pressure, but here is such a correlation with diastolic pressure ($r = 0.389$, $p < 0.05$). Analogous connection was found by Babadzhanov (4) in hypertensive patients.

Losse et al. (5,6) demonstrated that differently from patients with hypertensive disease, in case of renal hypertension the sodium concentration in erythrocytes is not elevated. The authors concluded that this difference is so constant that it may serve as a test in differential diagnosis. According to our data, this rule is also valid in hypertension due to aortic coarctation.

There was no correlation between the concentrations of electrolytes in plasma and erythrocytes neither in the control group nor in those operated on. According to our data it is impossible to evaluate water and electrolyte metabolism as a whole nor to calculate the concentration of any other electrolytes, starting from the values of one electrolyte. The only significant correlation existed between sodium and chloride in the urine.

Beginning with the first postoperative day the concentration of sodium and chloride dropped in the plasma. The minimum values were reached on the 3rd day and they were normalized on the 14th day after the operation. Such postoperative hyponatremia or -chloremia in the plasma was earlier described by other authors /Moore, (7), Zimmermann et al., (8,9) etc./. There are two possible explanations: the reason may be either blood dilution or sodium entering into the cell. The calculation of sodium and chloride in mEq. for 100 g dry weight showed us that the shift was caused by an elevated plasma water content.

The potassium concentration in the plasma water content increased beginning with the first postoperative day. The plasma water content in ml per 100 g dry weight was increased as well and became normalized only in two weeks. The reason for such a rise of plasma hydration is considered to be the water released in metabolism /Moore (7)/.

The sodium concentration in erythrocytes rose slowly, reaching its maximum on the 7th postoperative day. There were no changes in potassium, chloride nor water in the erythrocytes.

In all patients renal retention of water, sodium and chloride developed beginning with the 1st postoperative and intensified on the 2nd and 3rd postoperative days. Potassium excretion increased. Since a reason for sodium and chloride retention was evidently their increased resorption in renal channels, then elevated potassium excretion may be evaluated as a protective reaction of the organism to hyperkalemia in the plasma.

There were no changes of pCO_2 in the post-operative period. During the whole investigation a shift in acid-base balance to alkaline expressed by an increase of standard bicarbonates (SB) and a decrease of (BE) base excess was noted. The maximum increase of SB coincided with the lowest concentration of chloride in the plasma. It is quite natural, because chloride and bicarbonate may replace each

other in the extracellular fluid /Kerpel-Fronius (10)/.

The described changes occurred after all the operation types mentioned. The shifts were more pronounced in more traumatic operations.

Analogical shifts were described after different operations /Krokhalev, (11); Wise, (12); Miller et al., (13), etc./, but also in myocardial infarctions and burns /Borsov (14)/. Consequently, they cannot be regarded as specific for aortic operations. This reaction is one of the responses to any shifts in homeostasis and serves the vital interests of the organism during the stress situation, i.e. the preservation of the volume of blood and extracellular fluids.

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Changes in Water and Electrolyte Metabolism after Reconstructive Operations on Arteries

H. Tihane

Changes in the amount and ionic structure of the body fluids are regular reactions accompanying any trauma including an operation. The shifts are usually small, not causing any essential changes in the activity of organ systems and being soon corrected by the regulating mechanisms of the organism.

In case of severe operations with extensive injury of tissue and blood loss, changes in the balance of water and electrolytes develop. They should be quickly corrected to avoid states dangerous to the patient's life, such as oligoanuria, hyperkalemia, hypo- and hypernatremia, alkalosis, acidosis, etc. /1, 2, 3, 4/.

The factors causing changes in water and electrolyte metabolism are the following:

- (1) Changes in vegetative-endocrinous regulation as a response to the stress-situation (operation) /1,4/.
- (2) Blood loss and fluid sequestration into the region of tissue injury /1, 5, 6/.
- (3) Changes in the renal function /7, 8, 9, 10/.

There are undoubtedly numerous other factors influencing the homeostasis of the organism, but the three just listed are the main factors which must be taken into account especially while organizing post-operative infusion therapy because wrong infusion therapy may deepen the occurring shifts and cause states endangering life.

Proceeding from the above discussion, we have tried to study in the present paper how extensive are the shifts in water and electrolyte metabolism after reconstructive ope-

rations on arteries. For this purpose we determined the concentration of potassium and sodium in the blood plasma and the urine in 41 patients before the operation and in the course of 8 days after the operation. At the same time we observed changes in the values of hematocrit, erythrocyte mean volume and diuresis.

As a result of these investigations it turned out that the administration of 5% dextrose solution only may cause hyponatremia (120 mEq/L) together with arterial hypotension and the occurrence of other symptoms characteristic of "water intoxications" (dull headache, stupor, intensive perspiration, etc.). On the other hand, the administration of about 170 mEq sodium per day helps to avoid essential shifts in the plasma sodium concentration. Consequently, it seems to be suitable to administer 170 mEq sodium per day together with infusion solutions of 1.5 to 2.5 litres in the postoperative period to avoid hyponatremia.

Changes in the potassium concentration in the blood plasma are rather variable and mainly depend on the renal function. Thus we have discovered a negative correlation between the values of the potassium concentration in the blood plasma and diuresis ($r = -0.64$; $P < 0.01$). We observed perilous hyperkalemia (8.5 mEq/L) only in one patient who suffered from acute renal failure in the postoperative period. The data obtained are in agreement with information from the literature /9, 11/.

The plasma potassium concentration usually increases in the first postoperative days, reaching the preoperative level by the third or fourth day, after that decreasing below the preoperative level ($P < 0.01$), according to the normalization of diuresis. In the case of uneventful postoperative recovery we did not observe hypokalemia (lower than 3 mEq/L) requiring intensive treatment, so we confined ourselves to the oral administration of potassium (2 to 3 g per day).

Reduction of diuresis (at an average of 47 per cent of the preoperative level; $P < 0.001$) and decreasing sodium excretion (at an average of 35 per cent of the preoperative level; $P < 0.001$) are characteristic features of the first postoperative days. Both diuresis and changes in sodium excretion seem first of all to be connected with changes in the blood volume, because the reduction or end of infusions was followed by another lessening of diuresis and sodium excretion on the third or fourth postoperative day. Most investigators share the same standpoint /9, 11, 12, 13/. Beginning with the second or third postoperative day a trend towards increasing diuresis and sodium excretion occurs, but its values do not reach the preoperative level ($P < 0.05$) until the eighth postoperative day.

In case of complications (ileus, peritonitis) due to extensive changes in the blood and extracellular fluid, sodium excretion in the urine suddenly drops, reaching but a few mEq/L (1 to 2 per cent of that before the operation), although diuresis is retained within limits (1 to 1.5 l per day) as a result of intensive infusion therapy. At the same time the sodium concentration in the blood plasma is within normal limits or somewhat elevated (more than 150 mEq/L). Sodium excretion is increased according to the normalization of fluid space values.

On the other hand, potassium excretion is extremely variable in the postoperative period. Some rise in the excretion during the first postoperative days was not statistically significant ($P < 0.05$), although the potassium concentration in the urine was always elevated. An increase of diuresis in the postoperative period was attended by an increase of potassium excretion ($r = 0.5$; $P < 0.01$). In general, we have to agree with E. Carstensen /11/ that the determination of potassium excretion in the urine is of no essential diagnostic nor therapeutic significance in the postoperative treatment.

The coefficient of potassium-sodium in the urine as

an aldosterone activity indicator /14, 15/ was at an average of 2.76 ± 0.1 before the operation. In the first postoperative days the coefficient dropped to 45 per cent compared with the preoperative level ($P < 0.001$), indicating a rapid growth of aldosterone activity. This fact is in agreement with data in the literature /4, 9, 10, 14, 15/. Beginning with the third or the fourth postoperative day there was a trend for an increase in the potassium-sodium coefficient, reaching 92.5 per cent of the preoperative level by the 8th postoperative day.

In the first postoperative days the dynamics of hematocrit values was of twofold nature: in 70 per cent of patients the hematocrit value dropped by the 2nd postoperative day by 17 per cent of that before the operation; In 30 per cent of the patients, however, there was a tendency for hematocrit values to increase on the first postoperative day ($P < 0.05$), but it dropped to a level 15 per cent lower than that before the operation by the third or fourth postoperative day, remaining at about the same level in both groups until the end of the observation period. This preliminary growth could not be connected with blood transfusions. It seems to be caused by more extensive fluid sequestration (first of all the plasma) to the region of damaged tissues /1, 3, 6, 9, 13/. The reduction of hematocrit values in the postoperative period is caused by both infusion therapy and the transcapillary refilling of the vascular volume on account of interstitial fluid /1, 13, 17, 19, 20/. According to the Moore (1) concept of the hematocrit reduction and the blood volume deficit, it seems that almost a 1-litre deficit occurred in the patients described above in spite of blood transfusions (500 - 2,000 ml) during the operation. This was undoubtedly one of the main reasons for changes in diuresis and potassium excretion. At the same time infusion therapy is decisive in the composition changes of electrolytes in the plasma.

Summary

As a result of observations of 41 patients after reconstructive operations, it turned out that the extent of changes in the sodium concentration of the blood plasma is mainly determined by the sodium content of infusions. At the same time the potassium concentration in the plasma depends first of all on the extent of diuresis. The extent of diuresis and the daily excretion of sodium mainly depend on the volume of fluid therapy, resp. the size of fluid spaces, because the excretion of sodium characterizes more exactly changes in the fluid spaces, being an essential indicator for discovering the origin of complications. The dynamics of potassium excretion is less essential. Judging by changes in the hematocrit values, it turned out that we usually underestimate the amount of blood loss, often leaving a deficit of up to 1 litre.

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Management of Acute Renal Failure

H. Tihane

Acute renal failure (lower nephron nephrosis, crush syndrome, acute tubular necrosis, hemoglobinuric nephrosis, Schockniere, Chromoproteinniery) is an abrupt, frequently reversible impairment or cessation of renal function, clinically manifested by oliguria or anuria /1, 2, 3, 4/.

A patho-morphological substrate for acute renal insufficiency is often a tubular epithelial necrosis, but also acute glomerulonephritis, bilateral cortical necrosis (doppelseitige Nierenrindennekrose) and pyelo- or interstitial nephritis /3, 4, 5, 6, 7/.

J. Krumhaar et al. /5/ divide the etiological factors causing acute renal insufficiency into three main groups:

1. Hemodynamic lesions (shock, arterial hypotension, etc.).
2. Infectious-toxical lesions (peritonitis, exogenous intoxication, etc.).
3. Metabolic disturbances, hypo- and hypernatremia, hypokalemia, etc.).

It is often difficult to distinguish, however, the so-called functional renal insufficiency /7/ with intact kidneys, but disturbed conditions for its normal function (exicosis, arterial hypotension, blood loss, etc.) from acute renal insufficiency based on extensive lesions of the tubular system /4, 7, 8, 9, 10, 11/.

When not dependent on the character of the etiological factor, the clinical course of acute renal failure is usually uniform and three stages can be differentiated in it /7, 8, 11, 12, 13, 14, 15, 16, 17/.

1. The initial stage. This is a period when a damaging factor (ischemia, hypoxia, etc.) acts on kidneys causing morphological changes in the renal parenchyma. It lasts for 24 to 48 hours, whereas the symptoms of the underlying disease prevail in the clinical picture and the excretion of urine may remain within normal limits (30 to 40 ml per hour).

2. The insufficiency stage with concurrent anuria or oliguria, azotemia, hyperkalemia and acidosis. The mean duration of the insufficiency stage is 15 days during which changes in the homeostasis of the internal environment (hyperkalemia, azotemia, acidosis) can develop leading to death. The blockage of the tubular lumen with a necrotized tubular epithelium is considered to be the cause of anuria. If the patient survives this critical period, the third stage follows.

3. The restitutional or polyuric stage, the average duration of which is 15 days. At this stage the tubular lumen is cleaned, but a new epithelium has not yet been formed. That is why there are yet no reabsorptive-excretional processes. It results in the excretion of abundant, isotonic urine with potassium, sodium chloride and other ions, the so-called "electrolytic diabetes" /7/. Such intensive loss of water and electrolytes may cause exicosis and hypokalemia. Later the renal function normalizes, homeostasis is restored and the biochemical composition of the blood turns normal.

Consequently, morphological changes in acute renal failure are reversible and there are good prospects for recovery if therapy is carefully performed.

19 patients with acute renal failure grouped according to their etiological factors (Table 1) were treated at the Artificial Kidney Unit of Tartu in the period of April 13, 1966 - December 1967.

Table 1.

Etiological Factors in 19 Patients with Acute
Renal Failure

Factors	Number of Patients	Recovered	Died.
Trauma	2	1	1
Postoperative peritonitis	4	2	2(1 [*])
Incompatible blood trans- fusion	3	1	2(1 [*])
Excessive administration of roentgenocontrast medium (bilitrast)	1	1	0
Intoxication	3	3	0
Septic abortion	1	1	0
Myeloma	1	0	1
Unknown	3	3	0
Alcalosis	1	1	0

* Patients admitted in an extremely poor condition who died before extracorporeal hemodialysis was performed.

Judging by the Table 67 per cent of the patients recovered. Death was in no cases caused by renal failure, but by the underlying disease (peritonitis, hepatic necrosis, etc.).

When the patients were admitted, the values of residual nitrogen were 180 to 200 mg per cent, the potassium concentration in the plasma was below 6 mEq./l. Some dehydration, hyponatremia and acidosis usually occurred. If infusional therapy and the administration of 20 per cent mannitol (up to 2 g/kg of body weight) did not give desired results or if the patient's general condition deteri-

orated, extracorporeal hemodialysis was performed in patients with residual nitrogen exceeding 200 mg per cent (urea more than 400 mg per cent).

In all the patients to whom hemodialysis was applied oligo- or anuria had lasted for 1 to 5 days. The administration of mannitol (20 per cent) yields results only if oligo- or anuria has lasted less than 24 hours and tubular epithelial necrosis has not yet developed. The patients with functional renal insufficiency treated only with infusional and mannitol therapy without the application of hemodialysis are not discussed there. On the contrary, in patients with acute renal failure the administration of mannitol was not effective, this is corroborated by other authors /7, 8, 10, 17/.

Immediately before hemodialysis the biochemical composition of blood was as follows: mean residual nitrogen - 200 mg per cent (urea 400 mg per cent), plasma potassium 6.1 mEq/l, pH - 7.32; $p\text{CO}_2$ - 24.4 mmHg; BE - 11.9 mEq./l; BB - 33.4 mEq./l; SB - 14.9 mEq./l.

Hemodialysis was performed by means of the plate dialyser NIEHAI with a dialysis area of 1500 cm², capacity about 300 ml and average speed of blood flow - 200 ml per minute. The artificial kidney was connected with the blood circulation via the percutaneous catheterization of the femoral vein after Shaldon et al. /18/. The mean duration of dialysis was 6 hours.

As a result of hemodialysis the concentration of residual nitrogen was reduced at an average of 50 per cent. Potassium and sodium concentrations in the plasma were normalized. Moderate, compensated acidosis remained in the acid-base balance (pH - 7.36; BE - 6.9 mEq./l; SB - 18.1 mEq./l). Moderate alkalosis developed after repeated dialyses (2 - 3).

In 6 patients it was possible to confine oneself to 1 hemodialysis, a rise in diuresis and a gradual drop in the residual nitrogen and creatinine concentration up to

normal values followed. In other patients 2 to 11 hemodialyses with 3- to 6-day intervals were performed.

The patients usually tolerated the first and second hemodialyses well. In case of the following dialyses an extensive drop of arterial blood pressure with concurrent vomiting, nausea, etc., often occurred. In most patients it was easy to abolish arterial hypotension (below 80/30 mm Hg.) by the administration of 500 - 1000 ml of liquid and only in a few patients it was necessary to add vasopressor medicaments (noradrenaline). Venous pressure in the above-mentioned patients was comparatively low (20 - 30 mm H₂O), so the cause of a drop in the arterial blood pressure seems to be a decrease in the volume of circulating blood.

In 3 patients we noted the symptoms of brain oedema (restlessness, consciousness disorders, convulsions) at the end of hemodialysis or a few hours after it. These symptoms disappeared upon the administration of hypertonic solutions 20 per cent mannitol, 40 per cent dextrose, etc.). So-called "cerebral disequilibrium" should be regarded as the cause of brain oedema /16/.

A somewhat peculiar etiological factor sometimes occurred in patients with acute renal failure. In one of them it was caused by a myeloma leading to anuria and an uremic condition. The 50-year-old patient had not consulted any doctors during lifetime thus far and had been engaged in hard physical labour. There were no changes characteristic of myeloma either in the hemogram or the globuline fraction. The occurrence of the Bence-Jones protein in the urine was not checked. During more than 2 months hemodialysis was performed for 11 times, but there was no improvement in the renal function. Only autopsy revealed that there was a myeloma and the histological pattern of myelomnephrosis (*Myelomnephrose*).

In an other patient acute renal failure was caused by decompensated alkalosis. This 37-year old man had suffered for years from a stomach ulcer and he had constantly taken

bicarbonate. His blood pressure was high (200/120 mm Hg) and he had severe headaches. Immediately before the development of acute renal insufficiency the patient consumed ca 50 g of bicarbonate. After that profuse vomiting began. The patient collapsed and was hospitalized in an unconscious state. Convulsions, restlessness, temporary aggressiveness occurred. Diuresis remained within the limits of 1.5 to 2.1, but residual nitrogen increased to 195 mg per cent. Evaluating the acid-base balance, it turned out that he had an intensive decompensated metabolic alkalosis which disappeared during the dialysis (Table 2). At the end of dialysis the patient became quieter, he regained consciousness fully by the next day, but he did not remember what had happened.

Table 2

Acid-base balance before and after hemodialysis

Parameter	Before	After dialysis
pH	7.54	7.42
pCO ₂ (Partial pressure of carbon dioxide)	59.5 mm Hg	34.1 mm Hg
BB (Buffer base)	72.0 mEq./l	44.0 mEq./l
BE (Base excess)	+20.6 mEq./l	-1.6 mEq./l
SB (Standard bicarbonate)	52.0 mEq./l	22.6 mEq./l
Residual nitrogen	198 mg%	78 mg%
Sodium (in the plasma)	124 mEq./l	143 mEq./l
Chloride (in the plasma)	65 mEq./l	98 mEq./l
Potassium (in the plasme)	2,9 mEq./l	3.7 mEq./l

The biochemical blood indicators rapidly normalized and the patient was discharged 20 days later in a good general condition, without headaches, his blood pressure being

160/80 mm Hg. Two months later the renal function was normal and at present the patient feels well.

Patients with acute renal failure were discharged about 1.5 months after the latest hemodialysis, whereas all the biochemical blood indicators were within the normal limits. Blood sedimentation test still remained elevated and a trend to isostenuria occurred.

The follow-up of 6 months and 1 year after acute renal failure indicated a good general condition of patients. The renal function remains normal and the patients continue working at the same posts as earlier.

Conclusions.

13 (67 per cent) out of 19 patients with acute renal failure recovered. Death was not caused by renal failure, but mainly by the underlying disease (peritonitis, hepatic necrosis). Only renal failure due to myeloma could not be controlled and the patient died as a result of irreversible changes in the kidneys. The renal function usually improved after 1 to 3 hemodialyses so that further procedures were not necessary. Arterial hypotension during the dialyses should be connected first of all with a drop in blood volume evidently due to inadequate infusional therapy.

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Determination of Sex in Children with Anomalous External and Internal Genitals

U. Reino

The problem of timely and correct determination of sex in children with an anomalous formation of the genitals is of extreme significance, because it determines the further upbringing of the child. The position of man in society is so closely connected with the questions of sex that its correct determination is necessary not only in the interests of the patient, but also of the people surrounding him. Anomalous formation of the genitals leads to severe psychic traumas due to the patient's feeling of inferiority, which is acutely felt at puberty. This feeling is also revealed by the children of the pre-school age. If it is impossible to hide this defect in a collective, the abnormal body of the patient becomes an object of interest and mockery by the other children of the same age.

Up to now anomalous formation of sex has remained one of insufficiently elaborated and little discussed topics in child pathology. We have not been able to find any papers on the determination of sex published in the U.S.S.R. A limited number of papers on the anomalous development of the genitals deal with casual observations /K.P. Krasnovitov, (1); E.B. Lipsky, (2); A.M. Gasparyan, (3); I.B. Cherner, (4); G.D. Vorobyova. (5)/. The number of reports published abroad on the subject is also small /F.S. Howard, (6); J. Williams, (7); J.M. Morris, (8); F. Hinman, (9); E. Hamblen, (10); L. Wilkins, (11); A. Meeker, (12)/. These authors do not give sufficient methodical hints on how to study such patients.

A child is not an adult in miniature, but a creature growing and developing according to its own particular

laws /S.D. Ternovsky (13); S.J. Doletsky, (14); R. Gross, (15); M. Grob, (16); O. Swenson, (17)/. Due to special anatomical-physiological peculiarities of the child organism, the clinical course and the symptomatology of anomalous sex formation in children are of quite specific character. The decrease of the hormonal function of the gonads, the absence of secondary sexual distinctions and the infantile anatomical structure of the genitals are characteristic features of infancy. For this reason we try to determine sex taking into consideration the peculiarities of the tender age. When compiling the present paper, we set ourselves the following tasks: (1) to find out what developmental disturbances lead to the wrong determination of sex in children; (2) to work out rational methods for the examination of children with anomalous genitals; (3) to indicate optimum dates for the determination of sex and the changing of it if it has been preliminarily determined wrongly.

Our paper is based on the results of the clinical examination of 61 children with various forms of anomalous genitals treated at the Clinic for Pediatric Surgery (Head of the Chair - Prof. S.Y. Doletsky) of the Moscow Central Institute of Medical Proficiency and at the Department of Pediatric Surgery of the Tartu Municipal Clinical Hospital.

Among the anomalies of genital development causing difficulties for the correct determination of sex, pathological forms in which one and the same individual has both male and female genitals play a special role. Such anomalies are called hermaphroditism. The problem of the classification of developmental disturbances of the genitals making it difficult to determine the real sex of the child has not been finally solved yet. To a certain extent, this can be explained by the comparatively rare occurrence of developmental disturbances of the genitals in newborns. Having only a few individual observations at their disposal, most investigators have limited themselves to the description of difficulties met with in establish-

ing a diagnosis /N.Y. Fessenko, (18); M.T. Mamedov, (19); R.J. Caffery, (20); J.D. Arneaud, (21); W.L. Henry, (22); H. Hiekkala, (23)/. The concentration of patients with anomalous genitals at our clinics enabled us to accumulate experience and to establish a classification of 61 patients with doubtful sex into a number of main groups. In 57 patients the external genitals were formed after the hypospadiactype with unilateral or bilateral cryptorchism, representing various stages of the underdeveloped penis and the scrotum. Of these children, 30 patients were brought up as boys, 27 as girls. According to our observations, in certain forms of anomalous genitals of girls, especially those with the adreno-genital syndrome, the clitoris is enlarged and acquires the form of a hypospadiac penis, but the labia maiora resemble a scrotum. Various genitals, both male or female, in patients with anomalous external genitals of the hypospadiac type combined with cryptorchism may lead to a mistaken determination of sex in children. We observed 15 children whose real sex did not correspond to that in which they were brought up. Of these, 10 children who were girls by their real sex were being brought up as boys, and 5 children who were being reared as boys were in actual fact girls.

Among the anomalies of genital development expressed as hypospadias combined with cryptorchism, we established five large groups and several subdivisions. The classification elaborated by us need not be an original grouping of anomalous sexual formations, but it is a working scheme for general practitioners, indicating the main types of pathology leading to the mistaken determination of sex in a child. The classification and the corresponding grouping of children examined by us is given in Table 1.

Table 1.

Classification of anomalous genitals causing difficulties for determination of sex in children

Name of anomaly	Number of those examined
I Female pseudo-hermaphroditism	
A. Female pseudo-hermaphroditism of suprarenal origin or the adreno-genital syndrome in girls	
(a) congenital (hyperplasia glandulae suprarenalis)	27
(b) acquired (virilizing tumor of glandulae suprarenalis)	1
B. Female pseudo-hermaphroditism of non-suprarenal origin	1
II Male pseudo-hermaphroditism	
A. External genitals formed after the male type	7
B. External genitals formed after the female type	3
III True hermaphroditism	8
IV Underdevelopment of the testes	3
(a) absence of developed testes	3
(b) histologically changed underdeveloped testes	2
V Hypospadias combined with cryptorchism	9
	<hr/>
Total	61

Having investigated various forms of hermaphroditism according to the above classification, we noticed that female pseudo-hermaphroditism based on the adreno-genital

syndrome is of extreme practical importance.

The problem of timely and correct determination of sex is very topical since the decision taken by the doctor greatly influences the further fate of the child. The complicated nature of pathological forms requires the compilation of a detailed plan for the examination of such patients. The diagnosis of the various forms of disturbances of genital development externally expressed as hypospadias combined with cryptorchism is established on the basis of the data of anamnesis, objective clinical examinations, results of the study of hormonal changes in the organism and the structure of the internal genitals. Therefore when admitting a patient with hypospadias combined with cryptorchism to the hospital, we bear in mind cases when the genital glands cannot be discovered by palpation either in the scrotum or in the inguinal region. We recommend to examine such a patient according to the plan given in Table 2.

Table 2

Plan for the examination of patients with
anomalous genitals

- A. Anamnesis
- B. Objective investigation
 - 1. Examination
 - 2. Palpation
- C. Determination of hormonal changes in the organism
 - 1. Determination of 17-ketosteroids in daily urine
 - 2. Determination of bone age
- D. Structure of internal genitals
 - 1. Urethrovaginography
 - 2. Pneumopelviography
- E. Additional investigations
 - 1. Determination of genital chromatin
 - 2. Urethrovaginoscopy

3. Bimanual palpation under anaesthesia with relaxants
 4. Researches into the suprarenals after retroperitoneum
 5. Cortison test
- F. Diagnostic laparotomy

Diagnostic measures are taken in the order which makes it possible to determine sex in the case of frequent developmental anomalies whose diagnosis does not require complicated methods of examination or surgical intervention with a biopsy of the gonads.

The adreno-genital syndrome is a frequent anomaly causing difficulties for sex determination in children. Consequently, examination of the patient must lead to the exclusion or inclusion of the adreno-genital syndrome. In case of the exclusion of the adreno-genital syndrome, the observational data make it possible to establish a diagnosis of other varieties of anomalies and draw up a plan for treatment.

Having obtained a complete history of the case and carried out an objective examination, further investigations are performed in the following order: (1) determination of the 17-ketosteroids in the urine per day, (2) determination of bone age, (3) urethrovaginography, (4) pneumopelviography, (5) determination of genital chromatin.

In some cases the results of urethrovaginography and pneumopelviography are complemented with the data acquired by means of urethrovaginoscopy and bimanual palpation under the influence of relaxants.

Thus the comparison of clinical (rapid growth, absence of correlation between the calendary and the objective age, early hair growth, laboratory findings (increase of the 17-ketosteroids in the daily urine, genital chromatin of the female type) and roentgenological data (outstripping bone age) permit us to establish the diagnosis of the adreno-genital syndrome without surgical intervention. We must point out that in such a diagnosis anamnestic data are of

particular significance. If changes in the structure of the external genitals occurred in the postnatal period and underwent a rapid development, it is necessary in differential diagnosis to exclude the presence of suprarenal tumours. To exclude prevailing hormonal activities of tumour, a cortisone test is carried out and a roentgenological examination of suprarenals is performed after superimposing the retro-pneumoperitoneum. A positive cortisone test and uniform dimensions of the suprarenals allow us completely to exclude the existence of a tumour.

If data which might confirm the presence of the adrogenital syndrome are lacking, further differential diagnostic studies are carried out to ascertain hypospadias combined with cryptorchism, a form of pseudo- and real hermaphroditism or of underdevelopment of the male genital glands. To establish the diagnosis of hypospadias proper combined with cryptorchism, it is adequate to prove the absence of the internal female genitals and the existence of genital chromatin of the male type. In all the other anomalous forms of the genitals the investigations show similar results - the structure of the external genitals of the hypospadias type combined with cryptorchism, the normal content of the 17-ketosteroids in the urine, the existence of underdeveloped female internal genitals and uncharacteristic genital chromatin are noted. A distinctive characteristic in all these varieties of anomalies is the histological structure of the genital glands. Since the genital glands are in the majority of cases in the abdominal cavity, their discovery and histological study require a diagnostic laparotomy together with a biopsy of both gonads. The diagnostic stage should be combined with a therapeutic one, if possible. For this purpose a quick examination of the biopsy specimens of both gonads is made on the operating table, and having acquired histological data, the sex of the child is determined. Depending on that a corresponding therapeutic operation is carried out:

the excision of the genital glands and the internal genitals of the opposite sex or the lowering of the testicles. Thus we save the child from superfluous surgical intervention.

The proper evaluation of the results obtained in the course of objective, laboratory and roentgenological examinations in patients with an anomalous formation of sex makes it possible to explain the characteristic features of individual forms of anomalies and elaborate rational plans for treatment. The application of such objective methods of investigation according to an elaborate plan enabled us to establish the diagnosis without any surgical intervention and without a biopsy of the gonads in 38 of the 61 diseased children treated at our clinics on account of an anomalous formation of sex.

J. Money (24) used the following seven criteria for the determination of sex in patients: chromosomal sex, gonadal sex, sex of the external genitals, sex of the internal genitals, the sex in which a person was being brought up, the personal feeling of belonging to the male or the female sex, and psychosexual mentality depending on it. In normally developed men and women all these seven components correspond to a given sex. In patients with an anomalous formation of sex, the proper evaluation of the state of all the components of sex is infinitely more complicated. To determine their sexual belonging, it is necessary to bear in mind the following varieties: the chromosomal or genetic sex reflecting the chromosomal structure of an embryo after conception, the gonadal sex characterized by the histological structure of the genital glands; the hormonal sex indicating the prevalence of male or female genital hormones in the organism; the sex according to the internal genitals; the sex according to the external genitals; the sex in which a person is being brought up or the social sex (the sex according to documents), and lastly the state of personal feeling of

belonging to this or that sex and the psychosexual mentality. Our observations showed that in the anomalies of genital development it is necessary to take into consideration not only the set of the sex chromosomes of a given individual, the structure of the external and the internal genitals, the hormonal profile and the histological structure of the genital glands, but all these components taken together and in their interrelations. In cases when the sex of a child has been determined wrongly and should be changed, two important components - the sex in which the child has been brought up and the personal feeling of sexual belonging and the psychosexual orientation depending on it - must be taken into account. The role and interrelations of these components for the determination of the sex of the child in different age-groups is different. Analysis of our data shows that only objective indicators should be considered if the sex is determined at an early age, but in older children we must follow the combination of both objective and subjective components. We support the principle that the determination of the real sex of the child, but in certain cases a choice of the sex, must be performed at an age of up to 2 years, since after that age the child begins considering itself belonging to this or that sex. In addition to psychical factors, an important reason for an early determination of sex is the consideration that the optimum date for the first stage of surgical treatment of hypospadias is at an age of 1.5 to 2 years, but plastic surgical operations for hypospadias combined with cryptorchism must be preceded by the determination of the real sex of the child. Wrong tactics by the doctor - diagnostic determination of sex according to the structure of the external genitals or delay of complex investigations - may lead to the formation of the real sex in their older age when their feeling of genital belonging together with the psychosexual orientation have already taken shape. On the basis of our experience we think that

the changes of sex should be performed prior to the age of seven, i.e. before the child goes to school where the final formation of the psychosexual orientation takes place. When after that age the sex is determined and chosen for the further education of the child, the subjective components of sexual belonging (the sex in which the child is brought up, the feeling of belonging to the male or the female sex and the psychosexual mentality depending on it) become more and more decisive. When examining such a patient, it is necessary to carefully study its anamnesis and explain the details of the behaviour of the child. Changes of sex after the age of seven turn out to be impossible on account of a well-established feeling of belonging to a certain sex and due to the corresponding psychosexual orientation. In most cases the sex in which the child is being brought up coincides with the prevalent distinctions of the external genitals. That is why in older children it is necessary to organize the corresponding surgical and hormonal treatment, so that the children could be brought nearer to the sex in which they have been reared.

Conclusions:

1. It is difficult to determine the sex in children whose external genitals have been formed after the hypospadiactype combined with cryptorchism.
2. The structure of the external genitals of the hypospadiactype combined with cryptorchism may be expressed in five main varieties of anomalous sex formation: (a) female pseudo-hermaphroditism, (b) male pseudo-hermaphroditism, (c) real hermaphroditism, (d) underdeveloped male genital glands and (e) hypospadias combined with cryptorchism.
3. In order to determine the sex of the child properly, complete clinical, laboratory and roentgenological examinations are performed.
4. The determination of the real sex of the child with anomalous formations of sex is recommended to be carried out before 2 years of age.
5. A strictly individual approach is necessary in every concrete case for the change of sex if it has been preliminarily determined wrongly.

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Surgical Treatment of Children with
Anomalous Formation of Sex

U. Reino

The problem of the surgical treatment of children with an anomalous formation of sex has been so far superficially discussed in the literature. We have found only a few descriptions of operations /K. Jones, (1); I.H. Thompson, (2); A. Meeker, (3)/ without indication of the detailed techniques of the operation, the order of procedures and indications for them in children with anomalous formation of sex. The terms given for plastic operations on the external genitals seem to be debatable as well. This urged us to elaborate, and give reasons for, the dates and the order of surgical procedures, develop new techniques and improve on the existing methods of operation, introducing certain technical details leading to successful results at plastic operations. Having performed 100 operations on 57 children at an age of 11 days to 14 years (see Table 1.), we find it possible to establish certain general rules for the surgical treatment of children with anomalous formation of sex.

Table 1.

Name of operation	Number of operations performed
1. Amputation of enlarged clitoris	21
2. Plastic operation on external vaginal aperture	3
3. First stage of hypospadias plastic operation	22
4. Second stage of hypospadias plastic operation	10
5. Descensus of testicles	14
6. Excision of vagina	7
7. Diagnostic and therapeutic laparotomy	23

Total 100

In all the children examined by us the external genitals were formed after the hypospadiactype combined with cryptorchism. 30 children were brought up as girls, 27 as boys. Having determined their real sex, we performed the corresponding operations: in the girls the enlarged clitoris was amputated and a plastic operation was carried out on the external aperture of the vagina, in the boys a plastic operation on **hypospadias**, covering of the testicles, and removal of the female internal genitals were performed.

The extent of plastic operations in forming the external female genitals depends on the rate of masculinization of the external genitals. Our clinical examinations and 21 operations (clitorectomy) performed by us made it possible to distinguish four groups of patients depending on the character of the operations performed. A general feature of all the operations was the amputation of the enlarged clitoris and the making of an opening into the vagina. Surgical interventions in the patients of the first group were confined to the amputation of the enlarged clitoris. Operations on the patients of the second group were complemented with a resection of the skin fold over the entrance into the vagina. In patients of the third group the operation consisted of two stages: (1) amputation of the enlarged clitoris, (2) a plastic operation on the vagina. In these girls the vagina and the urethra formed sinus urogenitalis and the second stage of the operation included the separation of the vagina from the urethra, the descensus of the vagina and the formation of an entrance into the vagina. In patients of the fourth group the external genitals were completely formed after the male type. The complicated task to form female external genitals included the following items: (1) the removal of hypertrophic cavernosous bodies; (2) formation of pudenda maiora; (3) formation of the external aperture for the urethra and of an entrance into the vagina.

When correcting the male external genitals, plastic operations were carried out on hypospadias. The main task

of the first operation was the straightening of the penis, creating of normal conditions for its growth and development, which is a preparatory stage for urethroplasty to be performed in the following stage. Methods adopted at our clinics for the operations of the first stage on hypospadias include the excision of the rudimentary urethra and the following skin plastics using available triangular patches. The second stage is the formation of the urethra, which is the more responsible part in the therapy of hypospadias. The principal method of urethroplasty adopted at our clinics was suggested by D. Brown (4) and is based on the idea of the possible formation of the urethra out of the evolved skin folds which, being inserted under the subcutaneous layer, can turn it into a tube as a result of the process of epithelization round it. The operation of urethroplasty based on this principle is performed at our clinics with certain modifications /S.Y. Doletsky and I.A. Korolkova (5)/. As a result of these improvements, the number of postoperative complications was reduced threefold /I.A. Korolkova, (6)/.

Surgical tactics on boys with a vagina and an anomalous formation of sex have remained disputable up to the present day. Proceeding from our experience, we consider that in case of a considerable size of the vagina forming sinus urogenitalis or opening independently into the vestibulum, its removal is indicated, because its presence may aggravate urethroplasty and may cause postoperative complications. We have removed the vagina in 7 boys with anomalous genitals. Access to the vagina and the technique of the operation depend on the anatomical interrelations of the urethra and the vagina. In 5 patients the vagina opened into the urethra forming thus sinus urogenitalis, but in 2 patients there was an independent aperture into the vestibulum. In case of sinus urogenitalis, we remove the vagina in the course of a combined diagnostic and therapeutic laparotomy, While operating on the urethra, a metal catheter is insert-

ed into it to avoid its injury. The vagina is released from its surrounding tissue, sutured, tied up and resected. The vagina is tied up at a distance of 1 cm from the urethra so that the urethra would not get narrower. If the vagina opens separately into the vestibulum, we remove it by an incision into the perineum.

Laparotomy performed with the aim of correcting sex includes both diagnostic and therapeutic stages. Diagnostic laparotomy was performed by us in 23 patients, 21 of them with the following therapeutic stage. On the basis of our experiences we recommend the resection after Pfannestil to carry out laparotomy. The advantage of this kind of resection lies in the fact that it does not require any additional dissection of tissues for checking up the contents of the scrotum or the pudenda maiora and makes it possible to examine the inguinal regions. In the course of the operation it is necessary to consider the sites of the rudimentary female genitals, and not only be guided by their discovery in the small pelvis. In patients with anomalous formation of sex they may be located in the region penetrated by the testicle at its descent. The localisation of atrophic internal female genitals in patients examined by us was the following: (1) small pelvis in 12 patients; (2) at the internal opening of the inguinal canal in 6 patients; (3) hernial sac in 3 patients. In the presence of external distinctions of intersex in a patient and negative results of laparotomy with apparent absence of sources of intersex, one must not forget the possibility that the gonads of the opposite sex (or ovotestis) may be localised in the scrotum. That is why in a diagnostic laparotomy it is absolutely necessary to perform the biopsy of the genital glands in the scrotum or the pudenda maiora.

In determining dates for surgical intervention we observed the principle that the treatment of children should be completed in the pre-school age, so that they

might feel themselves to be fully valuable members of the child population. The child begins to feel clearly that it belongs to the male or the female sex at an age of about two years. Intercommunication in a child collective leads to the recognition of differences in its genitals from those of the other children. The defect that cannot be hidden becomes an object of mockery by other children. To save the child from superfluous sufferings, we think that the enlarged clitoris should be amputated before the age of two years. The second stage - the plastics of the external aperture of the vagina together with a correction of the external female genitals is put off by us until the period of puberty.

Most authors /E.S. Draginskaya, (7); A.E. Zvyagintsev, (8); V.P. Blair, (9); D. Browne, (10); E. Burns, (11); J. Barcat, (12)/ recognize the expediency of performing corrective operations on hypospadias in childhood. We support I.A. Korolkova's (13) views based on the results of work carried out at the Clinic for Infantile Surgery of the Central Institute for Medical Proficiency (135 operations of the first stage and 62 of the second stage). She concludes that the optimum date for the first-stage operation is the age of 1.5 to 2 years, but for the second stage 6 to 7 years with intervals not less than 6 months between the stages. Such terms are based on the following considerations. The existence of rudimentary urethra and fibrous cicatrix causing the twisting of cavernosous bodies slows down the growth of the penis. More frequent erections in the puberty period with a distinctly expressed crookedness leads in the long run to the permanent irreversible deformation of cavernosous bodies. The anatomical-physiological peculiarities of childhood, such as high regenerative ability of tissues, abundant blood supply, relative fragility of scars and fibrous cicatrix on the ventral surface of the penis and the absence of erections, lead to successful results of plastic operations. The earlier completion of the first stage permits to complete therapy by the time the child goes to school.

In our opinion the optimum date for the completion of the operation of lowering the testicles is the age of 6 to 7 years. Cryptorchism, especially its abdominal variety in patients with disturbances in the form of male pseudohermaphroditism, real hermaphroditism and the underdevelopment of the male genital glands require the lowering of the testicles at a comparatively earlier date compared with the dates generally adopted, even if we perform this operation as a therapeutic stage in the course of diagnostic laparotomy. Repeated cavity operations are painful for the child and we think that they do not justify themselves. The five operations performed by us at an age between 1 year 8 months and 5 years confirm the rightness of our tactics as to the earlier date of lowering the testicles. The removal of the vagina must be performed during the interval between the operations on hypospadias, i.e. at an age of 4 to 5 years. The dates for surgical operations and the order of corrective operations adopted at our clinics is reflected in Table 2.

Table 2.

Order and Dates for Surgical Procedures
in Children with Anomalous Formation of Sex

Nos.	Type of operation	Dates
<u>I. Correction of female external genitals</u>		
(1)	Amputation of enlarged clitoris	before 2 yr. of age
(2)	Plastics of external aperture of vagina	before puberty
<u>II. Correction of male external genitals</u>		
(1)	Straightening of penis	1.5 to 2 yr.
(2)	Excision of vagina	4 to 5 yr.
(3)	Descensus of testicles	6 to 7 yr.
(4)	Plastics of urethra	before 2 yr. of age
<u>III. Diagnostic and therapeutic laparotomy</u>		

Conclusions: (1) Surgical correction of genitals is indicated in all the forms of developmental disturbances and is performed after the determination of sex in children. (2) Diagnostic laparotomy with the biopsy of both gonads may be combined with a therapeutic stage - resection and subsequent removal of the genital glands, removal of the internal female genitals or descensus of the testicles in case of cryptorchism. (3) The choice of methods for the surgical correction of the genitals is performed considering the forms of pathology, individual peculiarities of the patient and the obligatory compilation of a perspective therapeutic plan. (4) Dates for surgical procedures adopted by us provide for the completion of therapy in the pre-school age.

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Division of Stomach Arteries in the Submucous Layer

U. Sibul

The development of modern gastric surgery needs more detailed knowledge about topographical peculiarities of the stomach blood vessels than is available in handbooks of anatomy and operative surgery /1, 2, 3, 4/.

The object of this work is to study certain angiographic features of the stomach, especially the submucous arterial network, to establish areas of the arterial blood supply of the main vessels.

Material and Methods

At postmortem examinations the arteries of 65 stomachs were pulsatively injected with a 10 per cent solution of gelatin and red lead simultaneously through the coeliac trunk and superior mesenteric artery at + 40° C and RR 120/60 mm Hg. After injections and X-ray exposure (first group vasographic study) all these specimens were opened along the great curvature. In 16 specimens the stomach wall was separated into two layers (seromuscular and submucous-mucous) under binocular lens control and studied after the X-ray exposure (second group vasographic study) by the stereomicroscope MBS-2.

The technique in the first group of X-ray exposures was 20 mA, 20 sec. and 45 kV, in the second group - 20 mA, 40 kV and 15 sec.

The whole surface of the stomach and the areas of the main blood vessel distribution in the submucous layer were planimetrically measured.

Results

Differences between the areas of the arterial blood supply of the main vessels were remarkable in the vasograms

of 40 adult stomachs. But in specimens taken from 10 newborns the division of the stomach based on the arterial system was impossible. In this age group the branches of the main blood vessels in the submucous layer extensively anastomosed each other without a clear difference between the areas.

The areas of the blood supply of the stomach arteries compared with the whole surface (measured planimetrically) were as follows (expressed in terms of percentage):

- 1) the left gastric artery 43 ± 0.37
- 2) the right gastric artery 9 ± 0.08
- 3) the right gastro-epiploic artery 18 ± 0.08
- 4) the left gastro-epiploic artery 8 ± 0.08
- 5) the short gastric arteries 13 ± 0.9
- 6) the recurrent branch (the left inferior phrenic artery) 6 ± 0.1
- 7) and the gastric posterior artery 6 ± 0.09
(Figs. 1 and 2).

The extent of the supply areas depends on the existence of accessory arteries. The supply area of the left gastric artery and the short gastric arteries was smallest in the presence of accessory arteries.

The size of the blood vessels in the submucous layer of the stomach body was the largest. The submucous arteries (SMA) of the cardio-fundic and pyloric regions greatly differed in their size and kind of branching. In the abdominal part of the oesophagus the SMA arise from subserous segmentary arteries. These run from one side of the oesophagus to the other and give penetrating branches to the submucous arterial network.

In the cardio-fundic area the submucous arteries arise mainly from the first great branch of the left gastric artery to the anterior wall and from the short gastric arteries.

In 64 per cent of cases the submucous arterial network

was supplemented by the gastric posterior arteries and in 88 per cent by the recurrent branch of the left inferior phrenic artery.

The SMA in the stomach body area arise from two large arterial arcades along the lesser and greater curvatures. On the anterior stomach wall 4 to 5 great branches of the left gastric artery run towards the great curvature and 3 to 4 cm from those anastomosed with the blood vessels of the great curvature.

The posterior stomach wall was supplied by 2 to 3 great branches of the left gastric artery.

On the anterior stomach wall the location of the main branches of the left gastric artery was more constant than that of the extraorganic main vessels.

In the region of the lesser curvature the thin submucous arterial network arises from small penetrating arteries outside the stomach, directly from the right and the left gastric arteries. There was a considerable difference in the size of the SMA in the upper, middle and lower thirds of the lesser curvature. The SMA were larger in the upper and smaller in the lower third of the lesser curvature.

In the pyloric region the SMA arise from two large arteries similar to the stomach body, but they did not form great arterial channels in the submucous layer.

Comments

The results of the present study revealed that the division of the stomach based on the arterial supply may be established by vasographic studies in the adult stomachs.

Several authors /5, 6, 7/ conclude that stomach division based on the arterial supply cannot be established, but they study mainly newborn stomachs.

Division of the stomach based on the lymphatic system was described by U.T. Takuloff /8/, but we did not

find a division based on arterial supply.

The references by numerous investigators /2, 3, 9, 14/ and our data /4, 15, 16/ indicate that extensive devascularisation after high resections (70 per cent and more) may lead to necrosis of the gastric remnant wall. The knowledge of the gastric blood vessel areas may help to prevent postoperative complications after high resections, especially in aged patients with arteriosclerotic involvement of the SMA /17, 18/. Together with a more extensive application of angiographic studies /19, 20/, these new details will be of greater importance.

Summary

The results of vasographic and stereomicroscopic studies of the stomach arterial blood supply were discussed. A division of the stomach based on the arterial system was established only in adult stomachs. A scheme of such stomach division is presented. Remarkable differences in extent and character of the stomach vessels, blood supply in the cardio-fundic and pyloric regions were noted.

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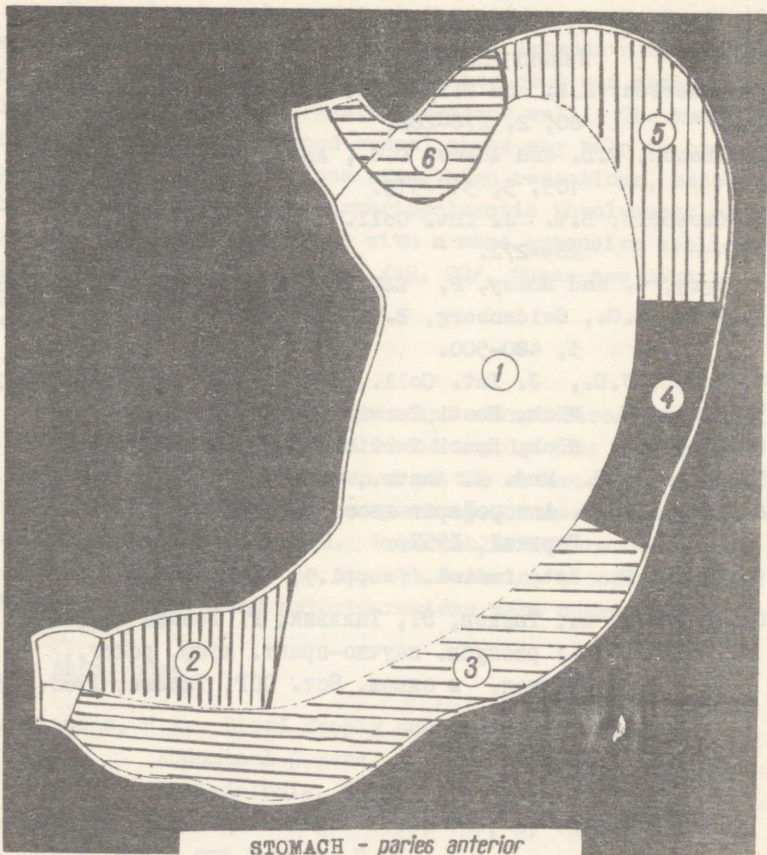


Figure 1 - The division of the anterior stomach wall based on arterial supply (the areas of distribution of the main stomach arteries in the submucous layer).

1. the left gastric artery
2. the right gastric artery
3. the right gastro-epiploic artery
4. the left gastro-epiploic artery
5. the short gastric arteries
6. the recurrent branch (the left inferior phrenic artery)
7. the gastric posterior artery (Figure 2).

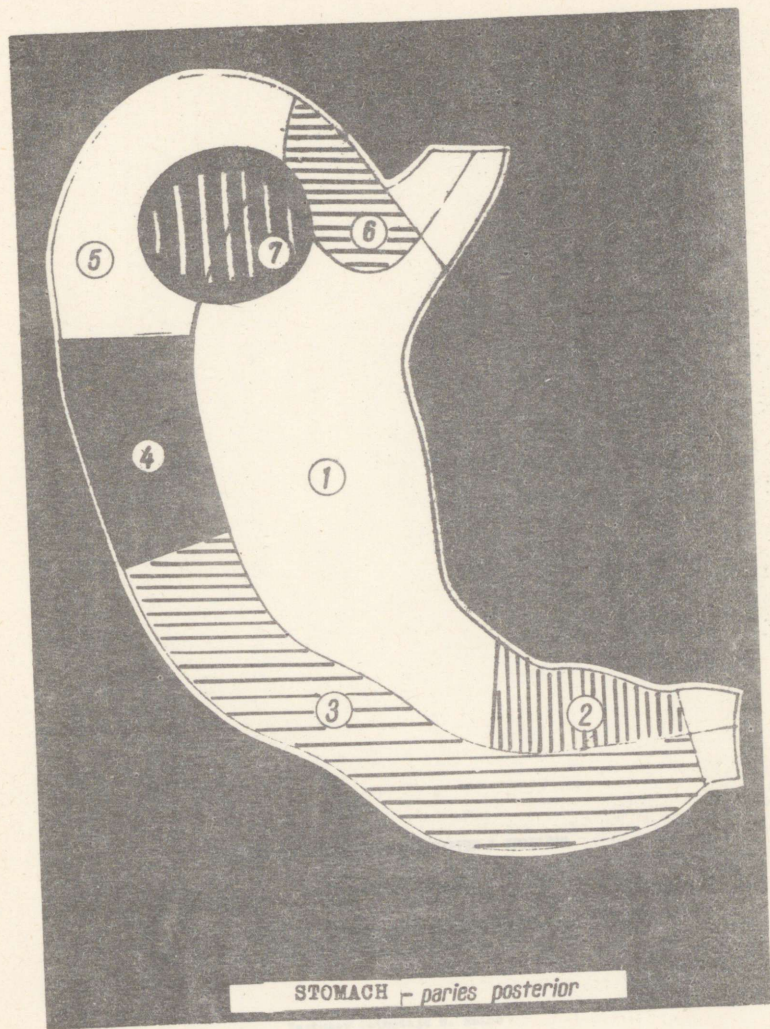


Figure 2 - The division of the posterior stomach wall based on arterial supply.



Figure 1 - The

ARTERIAL SUPPLY - STOMACH

1. the left gastric artery
2. the right gastric artery
3. the short gastric arteries
4. the left gastro-epiploic artery
5. the right gastro-epiploic artery
6. the recurrent branch (the left inferior phrenic artery)
7. the gastric posterior artery (Figure 2).

ПУБЛИКАЦИИ ПО СОСУДИСТОЙ ХИРУРГИИ И УРОЛОГИИ

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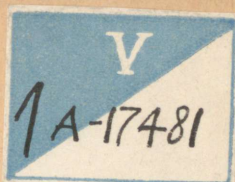
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